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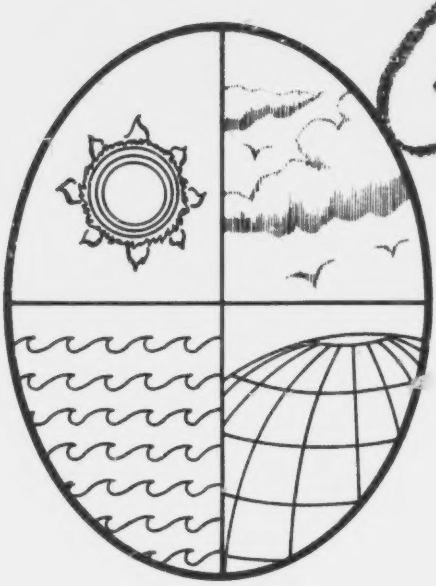

THE PHYSICAL DESULFURIZATION OF COAL

MAJOR CONSIDERATIONS FOR SO_2 EMISSION CONTROL

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The major economic factors which will affect the application of coal physically cleaned to 1% total sulfur content as an SO_2 emission control method for stationary power sources were examined. The individual cost factors associated with producing physically desulfurized coal and the economic benefit factors associated with the utilization of this coal were defined and quantified. Thirty potential physically desulfurized coal source/user combinations were analyzed to indicate the range of economic system variability to be expected.

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L. HOFFMAN
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ABSTRACT

This Technical Report examines the major economic factors which will affect the application of coal physically cleaned to 1% total sulfur content as an SO_2 emission control method for stationary power sources. were examined.

The individual cost factors associated with producing physically desulfurized coal and the economic benefit factors associated with the utilization of this coal were ~~are~~ defined and quantified. Thirty potential physically desulfurized coal source/user combinations were ~~are~~ analyzed to indicate the range of economic system variability to be expected.

FOREWORD

This document represents the results of a study performed for the Division of Process Control Engineering, National Air Pollution Control Administration (NAPCA), Department of Health, Education, and Welfare. This study effort was conducted during the period of April through October 1970 in support of planning activities for development of sulfur oxide emission control processes.

Special acknowledgement is given for the contribution to this effort by Dr. James Burton of MITRE. Dr. Burton contributed heavily to the organization of the task and the gathering and analysis of information contained in this report.

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GLOSSARY

Amortize	to provide for the gradual extinquishment of (as a mortgage) usually by contributing to a sinking fund at the time of each periodic interest payment
Benefication	the act or process (as applied to a raw material) so as to improve its physical and chemical properties
Cleaned Coal	coal beneficiated by a physical cleaning process
Depreciation	loss of value
F.O.B. Raw Coal Price	raw coal selling price without charge for delivery to and placing on board a carrier at a specified point
MBTU	million British Thermal Units
Physical Desulfurization of Coal	the separation of sulfur-bearing substance from coal by utilizing differences in the physical properties of the materials
Raw Coal Value	the operator's break-even price for providing a specified amount of raw coal (i.e., the expenses to produce a ton of raw coal including royalties, labor and equipment, insurance, taxes, and mine development costs, etc)
Run-of-Mine (ROM)	the raw coal (or ore) as it is delivered by the mine cars, skips, or conveyors and prior to treatment of any sort
Tariff	a schedule of rates or charges of a business or public utility
Yield	the ratio of output over input (expressible as a decimal or percentage)

1.0 INTRODUCTION

1.1 Objective

- Evaluate the economic factors involved in the production, transportation, and utilization of coal cleaned to 1% or less sulfur content.

1.2 Background

The recent introduction of regulations restricting the sulfur content of fossil fuels consumed in stationary operations have a fundamental impact on fuel supplies. Stationary fossil fuel burning operations, primarily electric utility and industrial, currently emit more than 25 million tons of SO_2 annually into the atmosphere. Of this total, more than 80% is contributed by coal burning operations concentrated in the urbanized areas east of the Mississippi River. The environmental threat posed by these concentrated SO_2 emissions has led to a trend in local regulations, interpreted from NAPCA air quality criteria, which either limit the sulfur content of fuel or restrict SO_2 emissions.

Prior to the introduction of these SO_2 emission regulations, utility and industrial consumers selected fuel based on the lowest cost per unit of heat. As a result the lower cost, higher sulfur coal sources, not useable by the metallurgical industry, have supplied about 70% of the fuel demands of stationary operations in the coal competitive markets of the Eastern United States. Since these coal supplies average about 2.5 percent sulfur content, the use of 1.0 percent sulfur content fuel could potentially produce a 60% reduction in the quantity of SO_2 emitted.

Although it is clear that SO_2 emission control will increase the cost of combustion operations, this may be the lesser of two concerns. The greater difficulty in implementing SO_2 emission control regulations appears to be the identification of low sulfur fuel sources which can produce sufficient quantities to meet stationary power source coal demands in the Eastern United States. This fuel supply problem is summarized in Table 1-1.

TABLE 1-1

ESTIMATED FUEL REQUIREMENTS

1970 coal demand of stationary operations in the Eastern United	380 million tons
Estimated 1970 production of 1% sulfur content coal used by stationary operations in the Eastern United States	60 million tons
Remaining 1970 fuel demand for which sulfur emission control is desired	320 million coal equivalent tons

In addition the continued growth of the utility industry, forecast at a rate of 5% to 10% per year, can be expected to rely primarily on fossil fuels until at least 1990.[1,2]

The search for methods of rapidly meeting SO_2 emission control regulations without impacting on the productivity of existing coal burning utility and industrial operations has led to the examination of a number of potential emission control alternatives. The alternatives being examined include the following:

(1) **Physical Desulfurization of Fuel**

- Coal
- Oil

(2) Combustion and Post-Combustion SO_2 Removal Processes

(3) **Conversion of Coal to Liquid or Gaseous Fuel**

(4) Natural Low Sulfur Fuel

- Coal
- Oil
- Natural Gas

The importance of physical cleaning to achieve a low sulfur content coal through reduction of the pyritic sulfur content is enhanced by a number of considerations surrounding these potential SO_2 emission control alternatives. These considerations, described as follows, also indicate that no single solution will be technically or economically satisfactory for all stationary power source situations.

1. The cost factors affecting stationary power sources in conversion from coal to other fossil fuel forms.

2. The research or prototype development status of combustion, stack gas, and coal conversion processes. This limits their widespread commercial application until at least 1975.

3. The limitations in the supplies and existing distribution capability of natural gas and low sulfur oil for additional utility and industrial application.

4. The low potential for a five-fold expansion of natural low sulfur coal production to meet the current demands of stationary power operations in the Eastern United States.

In the face of all these considerations, the physical or "deep"-cleaning process which uses existing coal preparation techniques to reduce pyritic sulfur content is an SO_2 emission control possibility worthy of detailed technical and economic evaluation.

This report presents the results of a task established to evaluate the economic considerations in the production, transportation, and utilization of coal physically cleaned to a total sulfur content of less than one percent. The results provide an evaluation tool to NAPCA for determining the role of physically cleaned coal in satisfying both sulfur oxide emission control regulations and the fuel demands of stationary power source coal consumers in the Eastern United States.

1.3 Approach

The task effort is directed toward quantifying the economic factors which will affect the role of physically cleaned coal in meeting SO_2 emission control regulations and its resulting relationship to other SO_2 emission control alternatives.

The essential variability of the economic factors surrounding clean coal require each coal source/user combination to be evaluated individually. Therefore, cost analyses are performed on thirty individual source/user cases to evaluate the net economic effect of the production, transportation, and utilization of physically cleaned coal. The analysis procedure is converted into a computerized cost analysis model for rapid evaluation of the net economic effect of any combination of source/user variables including the F.O.B. raw coal price.

1.4 Description and Content

The detailed results of this task are presented in total in this document. This document is organized as follows:

- Section 2.0 presents a summary of the task results.
- Section 3.0 presents the primary conclusions and recommendations drawn from the study.
- Section 4.0 develops an estimate of the location, production, and reserves of coal sources potentially cleanable to a 1% total sulfur content.
- Section 5.0 describes and quantifies the primary cost factors associated with the production of clean coal.
- Section 6.0 describes and quantifies the assessable economic benefits associated with the transportation and utilization of clean coal.
- Section 7.0 summarizes the cost/benefit analysis for physically cleaned coal in terms of 30 potential source/user combinations.
- Appendices I through VII present supporting information and detailed portions of the task study effort.

2.0 SUMMARY

2.1 Cleanable Coal Sources

Background data on the location, production, and reserves of potentially cleanable coal sources serving the Eastern United States are developed. These data provide perspective on the application of physically cleaned coal relative to alternative SO_2 emission control procedures.

Efforts to estimate the location, current production, reserves, and composition of coal sources potentially cleanable to 1% total sulfur content must consider the fundamental variability in size and concentration of the pyritic sulfur and ash forming impurities in coal. As a result, the several thousand quantitative coal analyses available in the literature are used in this study to develop coal composition probability distributions as a function of cleanability conditions. Based on this distribution, local trends in cleanability potential are defined on a state, county, and coal seam basis.

Estimates on the production and reserves of coal cleanable to 1% total sulfur are dependent on the cleaning conditions used. For the purpose of this study, estimates were based on a 3/8 inch crushing top size. This size may be considered as the minimum for practical transportation by open train, barge, or truck. A heavy media separation with ~90% BTU recovery was considered, based on available laboratory scale quantitative cleanability analyses. The result of the estimation process for non-captive bituminous coal production in states east of the Mississippi is indicated in Table 2-1 and Table 2-2. Cleaning conditions tailored to the specific characteristics of each cleanable coal source may be expected to increase the values indicated in Table 2-1 and Table 2-2 by as much as 50%.

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TABLE 2-1

ESTIMATED PRODUCTION OF BITUMINOUS COAL CLEANABLE TO 1% SULFUR CONTENT - BY STATE (1968)*

(Developed in Section 4.0 and Appendix I)

STATE	TONS
PENNSYLVANIA	19,000,000
WEST VIRGINIA	9,800,000
ILLINOIS	4,300,000
VIRGINIA	3,500,000
ALABAMA	2,500,000
KENTUCKY	2,100,000
INDIANA	1,900,000
TENNESSEE	1,300,000
OHIO	1,200,000
MARYLAND	400,000
TOTAL	46,000,000

*This production estimate is for non-captive coal production in states east of the Mississippi which is marketable to stationary power sources. The cleaning conditions considered are 3/8 inch top size crushing and separation at 1.60 specific gravity.

TABLE 2-2

ESTIMATED PRODUCTION AND RESERVES OF COAL CLEANABLE TO 1% SULFUR CONTENT-BY REGION (1968)*

(Developed in Section 4.0)

REGION	Production (10^6 Tons) 3/8 inch 1.60 Specific Gravity	Mine Reserves (10^6 Tons)* 3/8 inch 1.60 Specific Gravity	Recoverable Reserves (10^6 Tons)* 3/8 inch 1.60 Specific Gravity
NORTHERN APPALACHIAN	25	510	12,000
SOUTHERN APPALACHIAN	13	260	8,000
MIDWESTERN	8	150	3,000
TOTAL	46	920	23,000

*
- Mine reserves indicate the estimated future production of operating mines currently producing cleanable coal.
- Recoverable reserves indicate the estimated deposits of cleanable coal which could be recovered by current mining technology (i.e., a recovery factor of 50%).

2.2 Coal Cleaning Costs

This task effort investigates the economic factors associated with physically processing raw run-of-mine coal to produce a product with sulfur content less than 1%. The cost of providing a ton of this "deep"-cleaned coal, at the cleaning plant site, is the sum of the following variable factors:

- The cost of the raw coal that is required to produce a ton of clean coal.
- The share of cleaning plant amortization cost chargeable against each ton of cleaned coal.
- The cleaning plant operation and maintenance (O & M) cost attributable (i.e., apportioned) against each ton of cleaned coal.
- The share of the cleaning plant property tax that is apportioned against each ton of cleaned coal.

In physical cleaning, a coal separation or selection process takes place. Some of the raw coal input to a cleaning plant ends up as a reject material. Therefore to obtain a ton of cleaned coal, more than a ton of raw coal must be used. The amount, in tons, of raw coal that is required to produce a ton of cleaned coal is equal to the reciprocal of the cleaning plant yield. In practice, coals considered for physical cleaning to 1% sulfur content, together with the characteristics of cleaning plants, result in a range of yields from 95% to 70%. Since coal prices are also subject to considerable fluctuation, a range of coal prices are considered by this analysis.

Depending on makeup, cleaning plant cost can vary from $3300 to $15,000 per ton hour input capacity for plants with minimum input capacities of 500 tons per hour. Practicing engineers, engaged in the design of coal processing plants, have estimated that a plant specifically designed to physically desulfurize the more readily cleanable coals to a 1% total sulfur content will cost on the order of $8,000 per ton hour input capacity. This value is for plants with input capacities of 500 tons per hour and above. For this report, it was assumed that the cleaning plant will be financed by a 10-year equal payment self-liquidating loan. This is in agreement with the Internal Revenue Service (IRS) allowable 10-year write-off period. Therefore, the portion of amortization cost attributable to a ton of cleaned coal is simply the yearly principal and interest payment divided by the number of tons of cleaned coal produced in a year. For example, a plant costing $8,000 per ton hour input capacity, financed by an equal payment 10-year 8% loan (interest on unpaid balance) and operated at 38.5% utilization will result in an amortization cost varying from $0.35 to $0.50 per ton output at plant yields of 95% to 70% respectively.

Cleaning plant operation and maintenance (O&M) costs were determined by examining historical O&M costs for plants of the general type and complexity as believed required to achieve a 1% sulfur content product from the more readily cleanable coals. These historical O&M cost data were analyzed to obtain cost as a function of plant yield. The resulting data were then modified by information obtained from the U. S. Bureau of Labor Statistics in order to reflect current values. The resulting data indicate an average expected O&M cost per ton of cleaned coal ranging from $0.40 for a 95% cleaning plant yield to approximately $0.65 for a 70% cleaning plant yield.

State and local communities usually assess a property tax on fixed industrial assets. A state and local tax of 2% of the initial cleaning plant cost is assumed for this study. The tax burden allocated against each ton of clean coal is simply the yearly tax on the cleaning plant divided by the number of tons of clean coal produced. For a plant costing $8000 per ton hour input capacity and operating at 38.5% utilization, the property tax burden per ton of clean coal is estimated to vary between 5.0¢ and 6.8¢ per ton of clean coal for cleaning plant yields of 95% and 70% respectively.

The total additional (or cleaning) cost in providing a ton of "deep"-cleaned coal is therefore the sum of the above cost factors less the value of a ton of unprocessed coal.

The quantification process must consider a wide range of possible coal source and cleaning plant conditions. Therefore the results of the evaluation of each economic factor are presented in graphical form in Section 5.0. The results indicate that any generalization of cleaning costs can be misleading and that each case must be considered indivually.

2.3 Assessable Benefits

The economic benefits associated with the use of clean coal are derived primarily from the reduction of ash content. These benefit factors may be summarized as follows:

- Increased coal dollar value as a result of higher heat content.
- Reduced transportation costs per heat content of coal shipped.
- Reduced ash handling and disposal costs to the coal user.
- Reduced coal grinding cost to the coal user.
- Reduced welfare costs based on amount of coal shipped.
- Reduced power plant maintenance costs.

The increase in heat content of coal after physical cleaning is due principally to a reduction in ash content. The monetary benefit (per cleaned ton) resulting from the increase in heat content is equivalent to the value of that fraction of a ton that corresponds to the increase in heat content. This benefit equals the F.O.B. price of unprepared coal times a multiplier factor K.

- $K = \frac{x}{1 + x}$ where x is the decimal increase in heat content after cleaning.

Since less clean coal need be shipped for a given heat content value, a transportation saving will be obtained. This savings on a per ton basis is equal to the shipping cost per ton of coal times a factor. This factor is equal to that fraction of a cleaned ton that contains a heat value equal to the increase in heat value on cleaning. Rail transportation costs were obtained from probable carriers for the source/destination case studies addressed in this report.

Clean coal contains less ash and has a higher heat content value than the coal from which it was prepared. The effective ash disposal saving per ton of coal burned is equal to the effective saving from lower ash content times an addition factor (greater than 1) to account for the fact that fewer tons of coal need be burned to supply a given heat content value. The effective ash disposal saving per ton of "deep"-cleaned coal burned amounts to:

- The cost of disposing of a ton of ash times x(1 + x), where _x_ is the fractional increase in coal heat content resulting from cleaning.

The saving in grinding cost is principally due to the fact that for a given heat content, less "deep"-cleaned coal need be ground. The effective saving in grinding cost per ton of "deep"-cleaned coal burned is the per ton grinding cost times the multiplier factor K, which is equal to the fractional reduction in coal burned. This study indicates that the cost to grind a ton of coal is about $0.25. Thus, for example, the saving amounts to about 2.3¢ if the heat value of coal increases 10% after physical cleaning.

Welfare contributions by the mine operator are based on coal shipped from the mine. This effective saving results from the need to ship less of the higher heat content "deep"-cleaned coal to satisfy a given heat content value. The effective saving per ton is $0.40 times the multiplier factor K representing that fraction of a ton of coal corresponding to the increase in coal heat content (via physical cleaning). This amounts to about 3.6¢ for a 10% increase in heat content.

Power plant maintenance cost saving estimates were derived from TVA supplied data. Maintenance cost data covering two identical steam power plants, each of which burned coals of different ash and sulfur contents, were examined. The data covered the consumption of approximately 74 million tons of coal. Coal-associated maintenance costs (for all examined items) were higher for the plant burning the higher ash and higher sulfur content coal. For the two plants, the average difference in ash content was 2.5% and 1.7% in sulfur content. The average difference in maintenance cost amounts to $0.116 per ton of coal burned.

The quantification of all the above benefit factors are also presented in graphical or table form in Section 6.0 because of the range of possible variables which must be considered.

2.4 Cost/Benefit Analysis

The essential variability of coal cleaning costs and benefits requires that economic evaluations be performed on an individual coal source/user case basis. Table 2-3 summarizes the economic range associated with each assessable cost and benefit factor defined by this study. The ranges are based on evaluation of thirty potential physically desulfurized coal source/user combinations in the Eastern United States. For the purpose of these evaluations, the economic factors may be combined into a cost-analysis model which consists of three basic elements:

- The cost of producing clean coal from a coal source of defined composition; i.e., sulfur and ash content.
- The variation in transportation cost involved in shipping clean coal from a defined source location to a defined user location.
- The savings accrued from utilization of clean coal.

The net effect of these elements defines the economics of clean coal utilization for a specific case. The thirty case studies examined indicate a net coal cost change to the clean coal user ranging from a $0.44/ton saving to a $2.63/ton cost increase based on an F.O.B. raw coal cost range of $5.00 to $7.00 per ton. This economic effect translates on a heat content basis, into a range from a 1¢/MBTU saving to a 9¢/MBTU increase. Figures 2-1 and 2-2 represent the economic distributions of

TABLE 2-3

ECONOMIC RANGE OF EACH COST AND BENEFIT FACTOR PER TON OF PHYSICALLY DESULFURIZED COAL

(Developed in Sections 5.0 and 6.0)

ITEM	RANGE (dollars/ton)
COST FACTORS:	
Amortization contribution	0.37 to 0.57
O & M charge	0.40 to 0.73
Raw coal value lost	0.13 to 3.84
Tax contribution	0.05 to 0.08
Total Cost	$0.94 to $5.22
BENEFIT FACTORS:	
Value of additional coal heat content	0.06 to 1.34
Transportation saving	0 to 1.06
Welfare saving	0.01 to 0.08
Ash disposal saving	0.03 to 0.58
Grinding cost saving	0 to 0.05
Plant maintenance saving	0.05 to 0.20
Total Benefit	$0.15 to $3.31

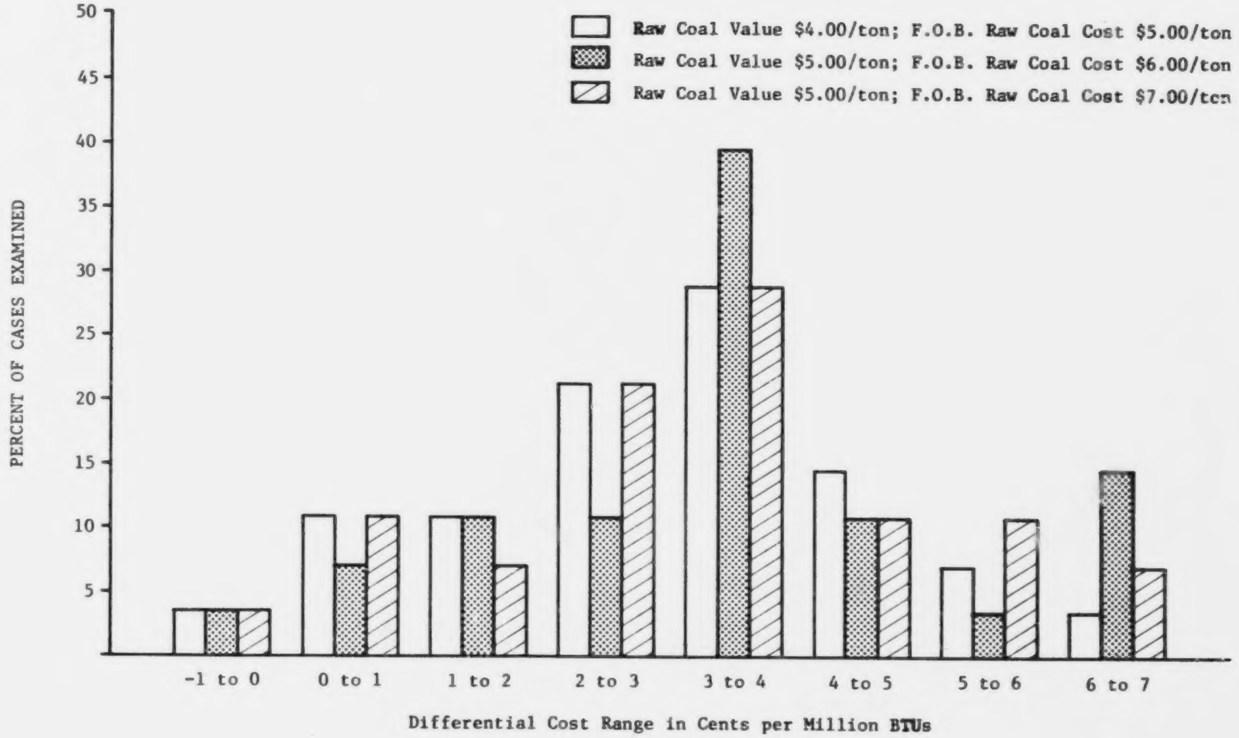

FIGURE 2-1
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - ¢/MBTU
(SINGLE CAR SHIPPING RATES)

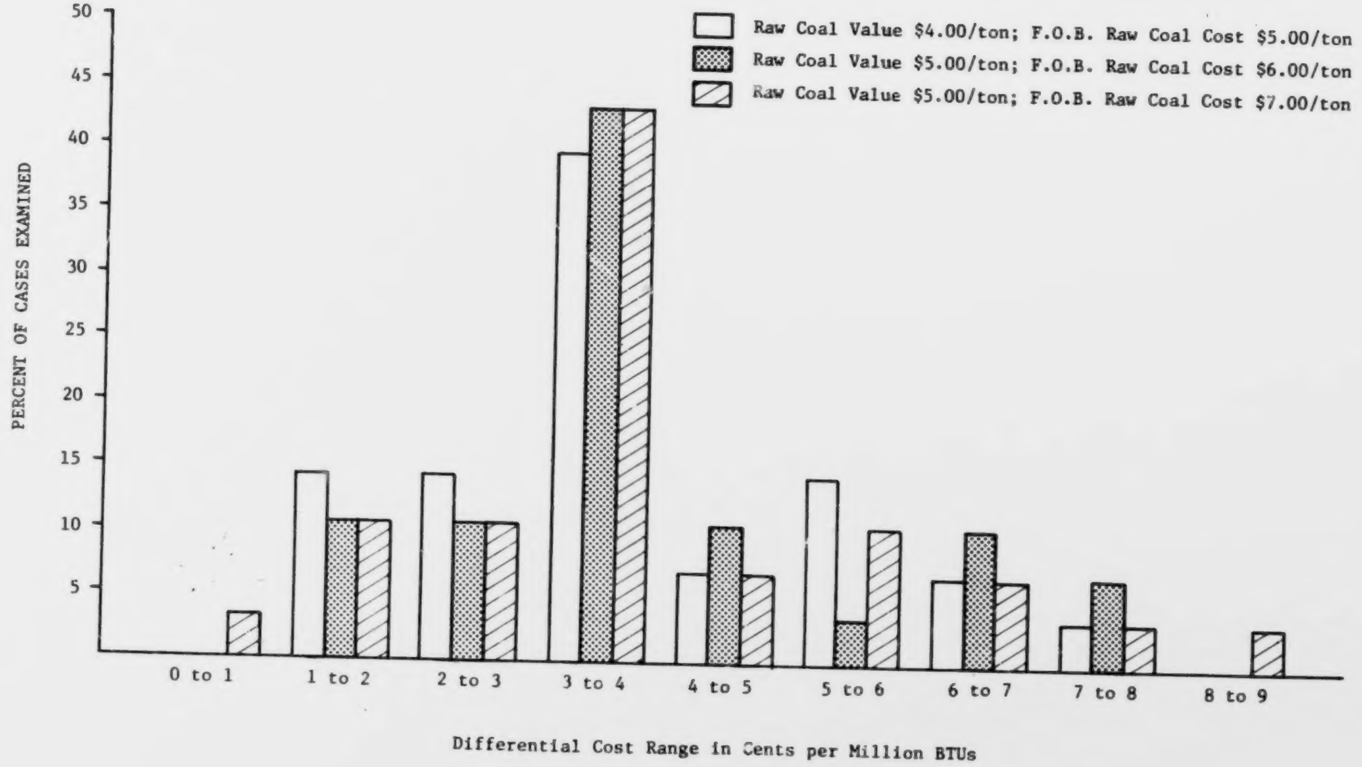

FIGURE 2-2
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - ¢/MBTU
(UNIT TRAIN SHIPPING RATES)

the case studies based on cleaning economics and the heat content of the physically cleaned coals considered. It is evident from Figures 2-1 and 2-2 (i.e. for single car and unit train shipping rates respectively) that in over 75% of the cases examined, the additional cost of using clean coal amounts to less than 5¢ per MBTU. Data supporting these figures are developed in Section 7.0.

As a result of these evaluations, a computer program is developed to simplify the valuation process. This program is designed to accept variations in the economic factors which contribute to each element of the cost analysis model. This program will quantify the net economic result for any specified cleanable coal composition and cost transported from a defined source location to a defined user location.

2.5 Potential Cleaned Coal Application

The approximately 46 million tons of current annual coal production which is estimated as cleanable to 1% total sulfur content under the conditions considered could satisfy about 15% of the low sulfur fuel needs indicated in Table 1-1. This would produce about an 8% reduction in the current atmospheric SO_2 burden in the Eastern United States. Although large reserves of coal potentially cleanable to 1% total sulfur can be identified, these require extensive new mine and mechanical cleaning facilities before production can satisfy the demands of the Eastern United States.

First order perspective on the utilization potential of physically cleaned coal can be achieved through estimation of its production and transportation cost relationships to the other indicated SO_2 emission control alternatives. These relationships may be combined with the production potential for coal cleanable to 1% total sulfur content to determine its impact on the coal market (See Appendix II). As a result, the region of greatest application is estimated as encompassing heavily industrialized and urban Eastern Ohio, Maryland, Pennsylvania, and New York State. This considers the Northern Appalachian Coal Region as the coal source with the highest cleanable coal production potential. In this area, the current production of coal estimated as potentially cleanable to 1% sulfur content could provide up to 30% of the present stationary power source coal demand.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

1. Cost-benefit analyses of thirty potential clean coal source/user combinations indicate that economic generalizations are impractical. The range of combinations considered by this study indicates that the production, transportation, and utilization of physically cleaned coal of 1% sulfur content can produce a net cost change to the coal user ranging from a 1¢/MBTU saving to a 9¢/MBTU increase. This range is based on a raw coal value of $4.00 to $6.00 per ton and an F.O.B. raw coal price of $5.00 to $7.00 per ton. Thus each case must be evaluated individually to determine the current economic relationship of physically cleaned coal to the fuel now being used. The task results are structured to provide this flexibility.

2. Over 75% of the cases and conditions studied indicate a net fuel cost increase of less than 5¢/MBTU through the use of physically desulfurized coal. These case studies are considered representative of the range of economic conditions surrounding the production, transportation, and utilization of physically desulfurized coal in the Eastern United States.

3. The examination of economic cost and benefit factors associated with physically desulfurized coal indicates that individually the most significant factors are plant amortization, operating and maintenance costs, coal recovery after cleaning, and the increased heat content of the cleaned coal.

4. The estimated fuel cost change associated with the use of physically desulfurized coal indicates that this is an economically attractive SO_2 emission control alternative for stationary power plants under favorable supply/demand relationships. Physically desulfurized coal therefore becomes especially attractive, relative to combustion and post-combustion processes, in older plants whose generating units were installed prior to 1950. The coal tonnage demand of these older power plants in the Eastern United States is approximately equal to the estimated potential supply of bituminous steam coal physically desulfurized to a 1% sulfur content.

5. The costs of producing physically cleaned coal is highly dependent on tailoring cleaning conditions to match local coal composition and production factors. The limited current production capability of many potentially cleanable coal sources indicates that in the near term centralizing cleaning plants serving a series of mines may be the most practical solution. It is suggested that the results of this study may be used to plan specific cleaning plant locations and input capacity for potential future implementation.

6. The location, production, and reserves of coal deposits physically cleanable to a 1% total sulfur content can be estimated from published quantitative coal analyses. This estimate is most reliable in the Northern Appalachian Region and is particularly useful in relating the availability and cost of physically cleaned coal to other SO_2 emission control alternatives.

7. The current production of Eastern bituminous coal estimated as cleanable by physical methods to a 1% total sulfur content could potentially satisfy 15% to 20% of the current coal requirements of stationary power sources in the Eastern United States. This application would produce an 8% to 10% reduction in SO_2 emission in the Eastern United States.

8. The application of physically desulfurized coal is primarily limited by coal production and the cost considerations in modifying some stationary power facilities to accept modified fuel characteristics.

3.2 Recommendations

1. The scope of the economic analysis provided by this study should be expanded to reflect the total economic system within which specific industrial and electric utility coal users will judge the acceptability of physically cleaned coal relative to other SO_2 emission control alternatives. Factors to be considered include:

. The impact on the market price of cleaned coal resulting from the limited supply, together with the demands of consumer categories other than stationary power sources.

. The relative costs of alternative SO_2 emission control options to achieve equivalent sulfur dioxide emission levels.

. The compatibility of individual physically cleaned coal sources with individual user facility design, operating life, and fuel contract conditions.

- The effect of local coal production capability on cleaning plant size and location.

2. This study has shown that physically cleaned coal is an economically attractive SO_2 emission control alternative. It is recommended, however, that future efforts consider the physical desulfurization of each bituminous steam coal source to the lowest practical sulfur content rather than only 1%. Such an approach might examine several potential advantages as a function of cleaned coal sulfur content. Factors to be considered might include:

- The location and increased production of physically cleanable coal.
- The potential impact on reducing SO_2 emission by location.
- The increase in both supply of, and long term demand for, physically desulfurized coal and its relationship to combustion and post-combustion emission control processes. Such indications would tend to encourage investment in coal cleaning plants.
- Optimization of the NAPCA desulfurized coal and pyrite refuse "Total Utilization Concept."

3. The NAPCA approach of developing the physical desulfurization of coal as one alternative in a system of potential SO_2 emission control processes appears to be the most effective method of achieving air quality criteria. To enhance the achievement of these criteria, it is recommended that local regulations be uniformly based on SO_2 emission. Regulations based only on SO_2 emission provide stationary power sources the latitude to implement the optimum emission control alternative consistent with their specific situation.

4.0 CLEANABLE COAL SOURCES

4.1 Introduction

Two coal source factors are analyzed to provide perspective and background information for this evaluation of the economic environment surrounding the use of physically cleaned coal in the utility and industrial fuel market.

- The location of coal sources potentially cleanable to 1% total sulfur content. This largely defines the transportation portion of the total delivered cost of cleaned coal to a defined user. For the purpose of this study, a coal source will be defined by region, coal producing district, state, county, and coal seam. The identification of coal sources by individual mine is not definable by the published data base because of the proprietary nature of the information.
- The quantity of cleanable coal produced by each cleanable coal source. Potential clean coal production, when related to utility and industrial fuel demands will place an upper bound on the extent to which coal cleaned to less than 1% total sulfur can meet the fuel requirements of these user categories. This upper bound can be further modified by comparing the economic analysis presented in this paper with the delivered costs of the other SO_2 emission control options available to the user. In this manner, perspective on the practicality of the clean coal

SO_2 emission control alternative for a given locality may be achieved both in terms of supply and cost. The production of each source will also define the practical size of cleaning plant which should be constructed and the type and frequency of transportation service which can be supported.

4.2 Scope of the Cleanable Coal Source Evaluation

This study will direct its evaluation of the Midwestern, Northern Appalachian, and Southern Appalachian bituminous coal regions which satisfy the utility and industrial coal markets of the Eastern United States. These coal regions are described in Appendix I.

Although large reserves of coal exist in the Western Region, these are considered outside the scope of this study for two reasons:

- The coal sources generally have a total sulfur content less than 1%.
- The coal sources are generally of lower rank with a heat content per unit mass only 50% to 75% that of Eastern bituminous coal. This factor, coupled with transportation distances, currently limit the economic competitiveness of Western coal sources in Eastern fuel markets.

4.3 Identification of Potentially Cleanable Coal Sources

If physical coal cleaning methods are to be used to achieve a sulfur content limit, then this implies that the raw ROM coal source must contain less organic sulfur than that limit. Thus, for consideration in this study, the organic sulfur content of a raw ROM coal source must be less than 1%. In addition, the candidate sources, of course, must have a total sulfur content greater than 1%.

An examination of the data base indicates that at one time or another the majority of the coal producing counties, particularly in the Northern Appalachian and Southern Appalachian Regions, have produced coal analyses meeting these basic cleanability criteria.[5,7,9,10] Therefore, the question is one of determining the degree to which samples which meet the basic cleanability criteria are typical of the coal sources from which they were taken.

Table 4-1 lists the coal sources in the Midwestern, Northern Appalachian and Southern Appalachian Regions which indicate possible potential as sources of coal cleanable to 1% total sulfur content, based on the analyses available in the data base. This potential is indicated by the degree to which analyses meeting the basic cleanability criteria are representative of the source. Representativeness is indicated in Table 4-1 in terms of the following three categories:

- A - Percent of coal analyses meeting the cleanability criteria (i.e., less than 1% organic sulfur and greater than 1% total sulfur).
- B - Percent of coal analyses having an organic sulfur content greater than 1%.
- C - Percent of coal analyses having a total sulfur content less than 1%.

TABLE 4-1

COAL SOURCES INDICATING POTENTIAL FOR CLEANABILITY TO 1% TOTAL SULFUR

SEAM	STATE	DISTRICT	COUNTY	A*	B*	C*	% ORGANIC SULFUR CONTENT (90% of OBSERVATIONS in A)
NORTHERN APPALACHIAN REGION							
COAL SEAMS OF THE ALLEGHENY GROUP**	PENN.	1 and 2	ALL PENN. COUNTIES IN DISTRICTS 1 and 2	80%	5%	15%	0.4 - 0.7
	MD.	1	ALLEGANY GARRETT				
	W. VA.	1	GRANT TUCKER MINERAL				
		3	BARBOUR PRESTON RANDOLPH				
PITTSBURGH REDSTONE	PENN.	2	ALLEGHENY FAYETTE GREENE WASHINGTON SOMERSET WESTMORELAND	50%	25%	25%	0.7 - 1.0
	W. VA.	3	BARBOUR GILMER HARRISON LEWIS MARION MASON MONONGALIA TAYLOR UPSHUR	30%	70%	0	0.7 - 1.0

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* A = PERCENTAGE OF ANALYSES WHICH HAVE ORGANIC SULFUR CONTENT LESS THAN 1% AND TOTAL SULFUR CONTENT GREATER THAN 1%

B = PERCENTAGE OF ANALYSES WHICH HAVE ORGANIC SULFUR CONTENT GREATER THAN 1%

C = PERCENTAGE OF ANALYSES WHICH HAVE TOTAL SULFUR CONTENT LESS THAN 1%

** THIS GROUP OF SEAMS INCLUDES THE UPPER AND LOWER FREEPORT; UPPER, LOWER, AND MIDDLE KITTANNING; AND BROOKVILLE SEAMS. IN MARYLAND AND WEST VIRGINIA, THE BAKERSTOWN SEAM IS ALSO INCLUDED.

TABLE 4-1 Continued

COAL SOURCES INDICATING POTENTIAL FOR CLEANABILITY TO 1% TOTAL SULFUR

SEAM	STATE	DISTRICT	COUNTY	A*	B*	C*	% ORGANIC SULFUR CONTENT (90% of OBSERVATIONS in A)
SOUTHERN APPALACHIAN REGION							
BLACK CREEK MARY LEE PRATT	ALA.	13	BIBB BLOUNT CULMAN DEKALB ETOWAH FAYETTE JACKSON JEFFERSON MARION MORGAN TUSCALOOSA WALKER WINSTON	40%	0	60%	0.5 - 0.6
CREECH/MASON	KY.	8	BELL HARLAN	30%	0	70%	0.6 - 0.9
STRAIGHT CREEK	KY.	8	BELL KNOX	30%	0	70%	0.6 - 0.9
PRINCESS	KY.	8	BOYD CARTER	30%	0	70%	0.6 - 0.9
HAZARD NO. 9	KY.	8	MAGOFFIN PERRY KNOTT BELL	60%	40%	0	0.6 - 0.9
HAZARD NO. 4	KY.	8	CLAY KNOTT	20%	0	80%	0.6 - 0.9
BIG MARY	TENN.	8	ANDERSON CAMPBELL MORGAN	20%	60%	20%	0.7 - 1.0
COAL CREEK	TENN.	8	ANDERSON CAMPBELL	20%	40%	40%	0.6 - 0.9
JELLICO	TENN.	8	CAMPBELL CLAIBORNE MORGAN SCOTT	20%	40%	40%	0.6 - 0.9
SEWANEE	TENN.	13	GRUNDY HAMILTON MARION RHEA SEWATCHEE VAN BUREN	20%	10%	70%	0.5 - 0.8

TABLE 4-1 Continued

COAL SOURCES INDICATING POTENTIAL FOR CLEANABILITY TO 1% TOTAL SULFUR

SEAM	STATE	DISTRICT	COUNTY	A*	B*	C*	% ORGANIC SULFUR CONTENT (90% of OBSERVATIONS in A)
CLINTWOOD	VA.	7 and 8	BUCHANAN DICKENSON RUSSELL WISE	40%	0	60%	0.6 - 0.9
	KY.	8	PIKE	20%	0	80%	
LOWER BANNER SPLASH DAM	VA.	7 and 8	BUCHANAN DICKENSON RUSSELL WISE	40%	0	60%	0.7 - 0.9
ALMA	W. VA.	8	BOONE LOGAN	80%	0	20%	0.6 - 0.9
	KY.	8	PIKE	20%	0	80%	
CEDAR GROVE	W. VA.	8	BOONE KENAWHA LOGAN MINGO	40%	0	60%	0.8 - 1.0
EAGLE	W. VA.	8	FAYETTE McDOWELL	20%	0	80%	0.6 - 0.9
FIRE CREEK	W. VA.	8	FAYETTE GREENBRIAR McDOWELL	60%	0	40%	0.6 - 0.9
HERNSHAW	W. VA.	8	BOONE KENAWHA	60%	0	40%	0.6 - 0.9
LOWER KITTANNING (No. 5 BLOCK)	W. VA.	8	CLAY KENAWHA	70%	0	30%	0.4 - 0.7
NO. 2 GAS	W. VA.	8	FAYETTE KENAWHA LOGAN MINGO RALEIGH	20%	0	80%	0.6 - 0.9
SEWELL	W. VA.	8	FAYETTE GREENBRIAR McDOWELL RALEIGH	60%	0	40%	0.6 - 0.9

TABLE 4-1 Concluded

COAL SOURCES INDICATING POTENTIAL FOR CLEANABILITY TO 1% TOTAL SULFUR

SEAM	STATE	DISTRICT	COUNTY	A*	B*	C*	% ORGANIC SULFUR CONTENT (90% of OBSERVATIONS in A)
MIDWESTERN REGION							
HERRIN (No. 6)	ILL.	10	FRANKLIN JACKSON JEFFERSON PERRY WILLIAMSON	40%	25%	35%	0.6 - 0.9
(NO. 5)	ILL.	10	FRANKLIN HAMILTON SALINE WILLIAMSON	70%	30%	0	0.7 - 1.0
IV VI	IND.	11	CLAY GREENE SULLIVAN VIGO	70%	30%	0	0.6 - 0.9
BLOCK	IND.	11	CLAY PARKE VIGO	40%	0	60%	0.7 - 1.0
NO. 6	KY.	9	BUTLER CHRISTIAN HOPKINS MUHLENBURG	30%	70%	0	0.7 - 1.0
NO. 6 (MIDDLE KITTANNING)	OHIO	4	ATHENS CARROLL COLUMBIANA HOCKING JACKSON MAHONING PERRY	60%	20%	20%	0.4 - 0.7
NO. 7 (UPPER FREEPORT)	OHIO	4	COLUMBIANA GUERNSEY HARRISON JEFFERSON	20%	0	80%	0.4 - 0.7
NO. 8A (REDSTONE)	OHIO	4	HARRISON MEIGS	20%	0	80%	0.7 - 1.0
PITTSBURGH	W. VA.	6	BROOKE	20%	0	80%	0.7 - 1.0

Only those sources for which 20% or more of the analyses are in Category A are included in Table 4-1, based on at least ten analyses per source. Also included is an indication of the organic sulfur content of each source in terms of the percentage range which would encompass 80% of the source analyses. The potential for cleanability of the coal sources indicated in Table 4-1 varies considerably from region to region and from District to District. These trends will be discussed in the following paragraphs.

4.4 Cleanable Coal Production

The fact that the sources described in Table 4-1 meet the basic cleanability criteria does not assure their physical cleanability to a 1% total sulfur content. For given cleaning conditions applied to a specific coal source, there is some maximum sulfur content for the raw run-of-mine coal above which cleanability to 1% cannot be practically achieved. This upper bound can be affected by two primary variables in the physical desulfurization process:

- Coal crushing size
- Conditions of separation

An estimation of cleanable coal production and exploitable reserves under defined cleaning conditions requires that a relationship be developed indicating the percentage of raw run-of-mine coal, at a given total sulfur content, from a given source, which is cleanable to 1% total sulfur. Appendix I describes this relationship as derived from published coal cleaning analyses for the 3/8 inch crushing top size and a heavy media separation at 1.60 specific gravity.[6, 9, 12]

The estimated production of coal cleanable to 1% total sulfur, from the sources identified in Table 4-1,at cleaning conditions of 3/8 inch crushing top size and 1.60 separation specific gravity,may then be derived by applying the sulfur removal relationships in Appendix I to coal production as published in References 3 and 7 and distributed by sulfur content according to Reference 4. The results are tabulated in Table 4-2. The results indicate that approximately 46 million tons of coal cleanable to 1% sulfur content were produced in the Eastern United States in 1968 under the chosen cleaning conditions. The estimated error range on this result is ± 15%,based on the boundary conditions for the sulfur removal relationships described in Appendix I. The general results of Table 4-2 are indicated pictorally in Figure 4-1.

Table 4-2 indicates the following coal production data by county:

(1) Total 1968 coal production

(2) Production which is captive to the metallurgical industry

(3) Net production (i.e., the total 1968 production minus captive production)

TABLE 4-2

ESTIMATED 1968 PRODUCTION OF COAL CLEANABLE TO 1% TOTAL SULFUR, BY COUNTY
(3/8 INCH CRUSHING, 1.60 WASH SPECIFIC GRAVITY)[3,4,7]

STATE	COUNTY	DISTRICT	TOTAL COUNTY COAL PRODUCTION (10^3 TONS)	ESTIMATED CAPTIVE PRODUCTION IN SEAMS OF INTEREST (10^3 TONS)	ESTIMATED NET PRODUCTION (10^3 TONS)	ESTIMATED NET PRODUCTION >1% SULFUR (10^3 TONS)	ESTIMATED PRODUCTION CLEANABLE TO 1% SULFUR (10^3 TONS)
NORTHERN APPALACHIAN REGION							
PENN	ARMSTRONG	1 and 2	6,653	0	6,653	6,653	2,900
	ALLEGHENY	2	5,100*	1,600	3,500	3,500	1,000
	BEAVER	2	500*	0	500	500	250
	BEDFORD	1	86	0	86	86	50
	BUTLER	2	1,946	400	1,550	1,550	450
	CAMBRIA	1	7,776	2,600	5,176	5,176	3,500
	CENTRE	1	706	0	706	706	300
	CLEARFIELD	1	6,160	0	6,160	6,160	3,200
	ELK	1	359	0	150	150	70
	FAYETTE	1 and 2	600	500	100	100	20
	GREENE	2	11,688	11,688	0	0	0
	INDIANA	1 and 2	6,648	0	6,648	6,648	2,900
	JEFFERSON	1	1,576	0	1,576	1,576	250
	LAWRENCE	2	1,012	0	1,012	1,012	200
	SOMERSET	1 and 2	4,100	0	4,100	4,100	2,400
	VENANGO	2	445	0	445	445	100
	WASHINGTON	2	13,500	10,300	3,200	3,200	900
	WESTMORELAND	1 and 2	3,000	700	2,300	2,300	580
	PENNSYLVANIA TOTAL		71,855	27,788	43,862	43,862	19,070
MD.	ALLEGANY	1	350	0	350	250	150
	GARRETT	1	1,100	0	1,100	1,070	300
	MARYLAND TOTAL		1,450	0	1,450	1,320	450
W.VA.	BARBOUR	3	3,518	400	3,118	3,118	600
	GILMER	3	100*	0	100	100	20
	GRANT	1	1,294	0	1,294	1,294	700
	HARRISON	3	9,000	0	9,000	9,000	50
	MARION	3	13,530	3,500	10,030	10,030	2,900
	MASON	3	348	0	348	348	50
	MONONGALIA	3	10,228	0	10,228	10,228	350
	PRESTON	3	2,245	0	2,245	2,245	1,100
	RANDOLPH	3	510	0	510	400	110
	UPSHUR	3	556	0	556	556	70
	W. VIRGINIA TOTAL		41,329	3,900	37,429	37,319	5,950
	NORTHERN APPALACHIAN REGION TOTAL						25,470

*ESTIMATED FROM MOST RECENT PUBLISHED PRODUCTION QUANTITIES

TABLE 4-2 Continued

ESTIMATED 1968 PRODUCTION OF COAL CLEANABLE TO 1% TOTAL SULFUR, BY COUNTY
(3/8 INCH CRUSHING, 1.60 WASH SPECIFIC GRAVITY)[3,4,7]

STATE	COUNTY	DISTRICT	TOTAL COUNTY COAL PRODUCTION (10^3 TONS)	ESTIMATED CAPTIVE PRODUCTION IN SEAMS OF INTEREST (10^3 TONS)	ESTIMATED NET PRODUCTION (10^3 TONS)	ESTIMATED NET PRODUCTION >1% SULFUR (10^3 TONS)	ESTIMATED PRODUCTION CLEANABLE TO 1% SULFUR (10^3 TONS)
SOUTHERN APPALACHIAN REGION							
ALA.	FAYETTE	13	190	0	190	150	70
	JACKSON	13	519	0	519	519	250
	JEFFERSON	13	8,359	5,800	2,559	1,800	1,000
	MARION	13	118	0	118	118	50
	TUSCALOOSA	13	675	0	675	675	400
	WALKER	13	4,321	2,205	2,116	2,000	700
	WINSTON	13	170	0	170	170	100
	ALABAMA TOTAL		14,352	8,005	6,347	5,432	2,570
E.KY.	BELL	8	3,244	0	3,244	300	150
	CLAY	8	2,000*	0	2,000	1,300	750
	KNOTT	8	2,297	0	2,297	600	100
	KNOX	8	153	0	153	70	30
	PERRY	8	4,316	0	4,316	800	150
	PIKE	8	19,619	2,122	17,497	1,500	800
	E. KENTUCKY TOTAL		31,629	2,122	29,509	4,570	1,980
TENN.	ANDERSON	8	2,104	0	2,104	2,104	600
	CAMPBELL	8	1,583	0	1,583	275	150
	CLAIBORNE	8	400*	0	400	250	150
	MORGAN	8	373	0	373	373	50
	SCOTT	8	600*	0	600	600	150
	SEWATCHEE	13	70	0	70	70	30
	VANBUREN	13	288	0	288	288	150
	TENNESSEE TOTAL		5,418	0	5,418	3,960	1,280
VA.	BUCHANAN	7 and 8	15,804	0	15,804	4,900	2,500
	DICKENSON	8	9,062	0	9.062	1,400	700
	WISE	8	8,554	0	8,554	575	300
	VIRGINIA TOTAL		33,420	0	33,420	6,875	3,500
W.VA.	BOONE	8	10,290	1,215	9,075	900	500
	CLAY	8	80*	0	80	80	40
	KANAWHA	8	11,682	3,100	8,582	2,700	1,400
	LOGAN	8	15,492	2,701	12,791	3,000	1,600
	McDOWELL	8	16,975	8,000	9,000	300	150
	W. VIRGINIA TOTAL		54,519	15,016	39,528	6,980	3,690
SOUTHERN APPALACHIAN REGION TOTAL							13,020

*ESTIMATED FROM MOST RECENT PUBLISHED PRODUCTION QUANTITIES

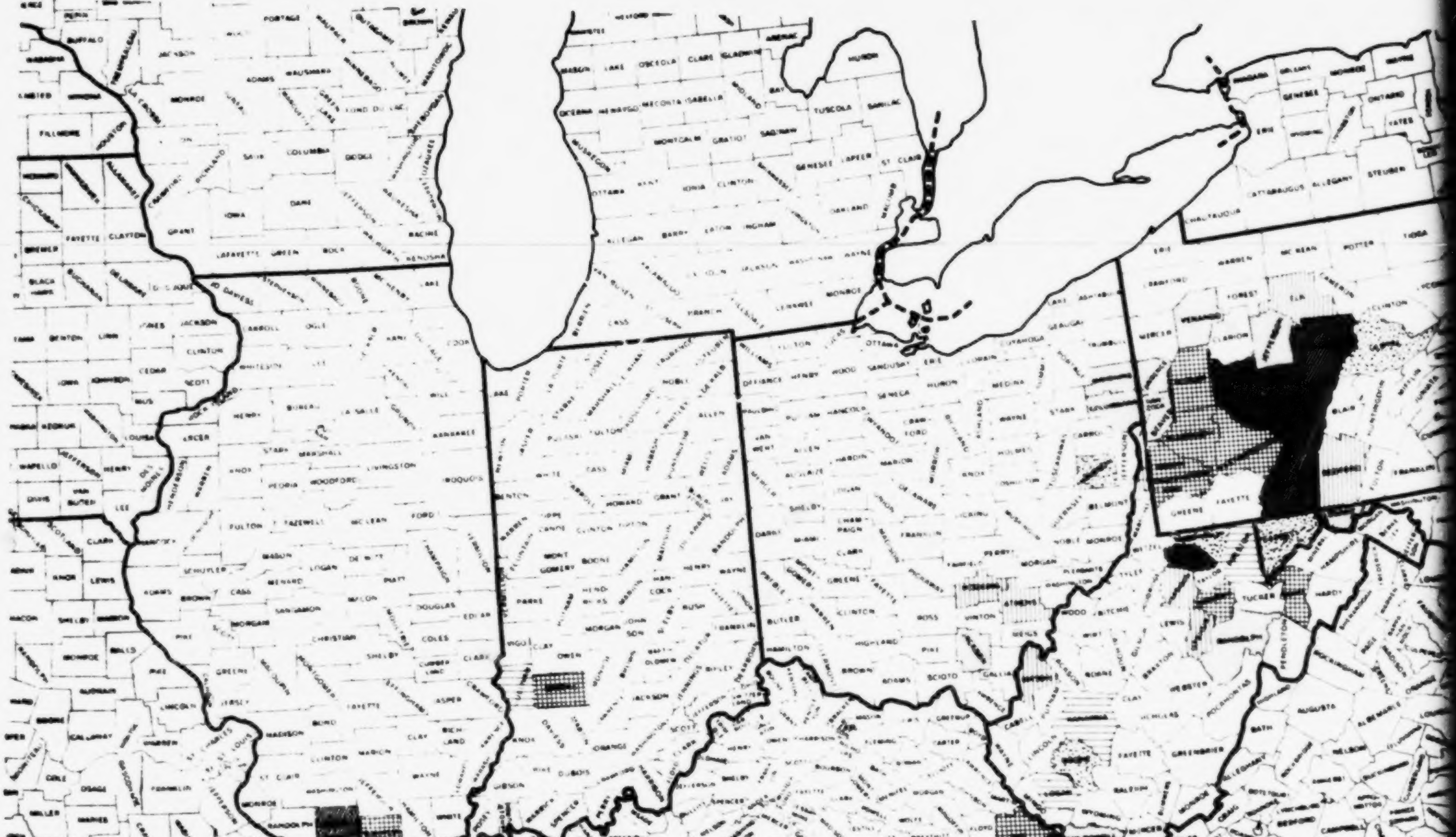
TABLE 4-2 Concluded

ESTIMATED 1968 PRODUCTION OF COAL CLEANABLE TO 1% TOTAL SULFUR, BY COUNTY
(3/8 INCH CRUSHING, 1.60 WASH SPECIFIC GRAVITY)[3,4,7]

STATE	COUNTY	DISTRICT	TOTAL COUNTY COAL PRODUCTION (10^3 TONS)	ESTIMATED CAPTIVE PRODUCTION IN SEAMS OF INTEREST (10^3 TONS)	ESTIMATED NET PRODUCTION (10^3 TONS)	ESTIMATED NET PRODUCTION >1% SULFUR (10^3 TONS)	ESTIMATED PRODUCTION CLEANABLE TO 1% SULFUR (10^3 TONS)
MIDWESTERN REGION							
ILL.	FRANKLIN	10	5,600*	0	5,600	5,600	700
	PERRY	10	10,411	0	10,411	10,411	3,000
	WILLIAMSON	10	4,857	0	4,857	4,857	600
	ILLINOIS TOTAL		20,868	0	20,868	20,868	4,300
IND.	GREENE	11	1,500*	0	1,500	1,500	700
	SULLIVAN/VIGO	11	4,400*	0	4,400	4,400	1,200
	INDIANA TOTAL		5,900	0	5,900	5,900	1,900
W.KY.	BUTLER	9	200*	0	200	200	100
	W. KENTUCKY TOTAL		200	0	200	200	100
OHIO	ATHENS	4	250*	0	250	250	50
	CARROLL	4	300*	0	300	300	20
	COLUMBIANA	4	1,133	0	1,133	1,133	250
	HARRISON	4	10,532	0	10,532	10,532	300
	HOCKING	4	131	0	131	131	50
	JACKSON	4	910	0	910	910	250
	JEFFERSON	4	5,000*	250	4,750	4,750	30
	MAHONING	4	778	0	778	778	250
	OHIO TOTAL		19,034	250	18,784	18,784	1,200
W.VA.	BROOKE	6	806	0	806	806	100
	W. VIRGINIA TOTAL		806	0	806	806	100
	MIDWESTERN REGION TOTAL						7,600
				COMBINED REGIONAL TOTAL			46,090

*ESTIMATED FROM MOST RECENT PUBLISHED PRODUCTION QUANTITIES

A



B

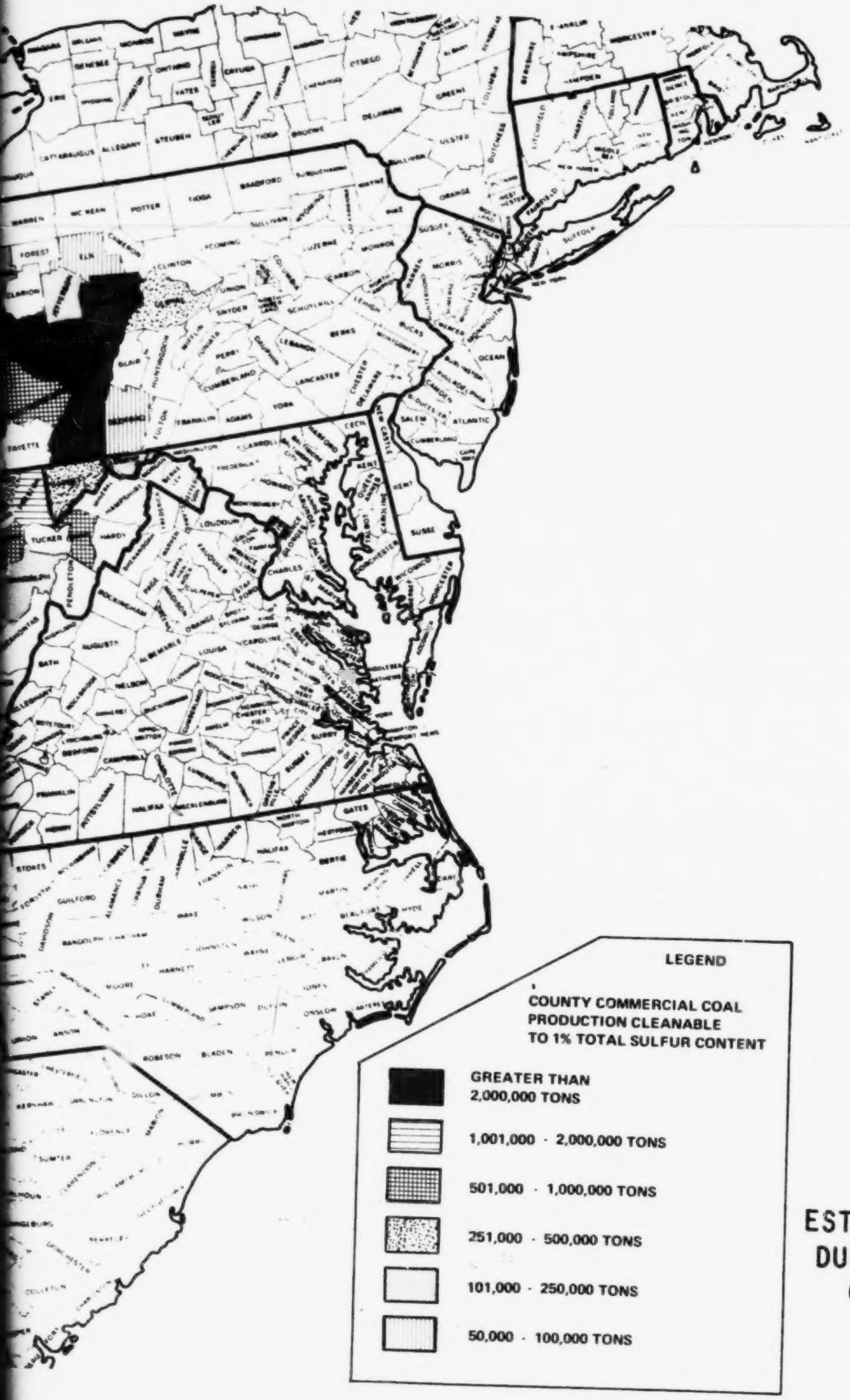

LEGEND
COUNTY COMMERCIAL COAL PRODUCTION CLEANABLE TO 1% TOTAL SULFUR CONTENT
GREATER THAN 2,000,000 TONS
1,001,000 - 2,000,000 TONS
501,000 - 1,000,000 TONS
251,000 - 500,000 TONS
101,000 - 250,000 TONS
50,000 - 100,000 TONS

FIGURE 4-1
ESTIMATED 1968 COMMERCIAL PRODUCTION OF COAL CLEANABLE TO ONE PERCENT TOTAL SULFUR

(4) The portion of the net production which is estimated as having a sulfur content greater than 1%

(5) The portion of the net production which is estimated as cleanable to 1% total sulfur content or less.

This estimated cleanable production quantity takes into account the suggestion in Reference 4 that the distribution of production according to sulfur content may be biased bacause of the inclusion of data from processed rather than raw run-of-mine coal. The reference indicates that the percent of sulfur in raw run-of-mine coal may be about 0.2% to 0.5% higher than indicated in the total sulfur content range which is considered reducible to 1% by physical coal desulfurization.

4.5 Reserves of Potentially Cleanable Coal

The reserves of potentially cleanable coal are considered in two categories. The first category is called mine reserves, which represent the probable remaining production of the working mines in the cleanable coal sources indicated by this study The second category is the total recoverable reserves of cleanable coal which might be exploited through development of new mines.

Mine reserves are estimated by multiplying the current production of cleanable coal as indicated in Table 4-2 by the average remaining operating life of the coal mines in each cleanable coal source in each region. This remaining operating life is indicated in Reference 7 and averages about 20 years for the sources examined.

Total recoverable reserves are the estimated quantity of remaining mineable coal reserves represented by the coal sources indicated in Table 4-2. This estimate is derived by applying the sulfur removal relationships in Appendix I to the published estimates of geological reserves and multiplying by a 50% coal recovery factor. [4,8]

The estimates of both mine reserves and total recoverable reserves are indicated in Table 4-3 for coal sources potentially cleanable to 1% total sulfur content.

TABLE 4-3

ESTIMATED COAL RESERVES CLEANABLE TO 1% TOTAL SULFUR*

(3/8" Top Size Crushing; 1.60 Wash Specific Gravity)

Region	Mine Reserves (10^6 tons)	Recoverable Reserves (10^6 tons)
Northern Appalachian	510	12,000
Southern Appalachian	260	8,000
Midwestern	150	3,000
Total	920	23,000

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[*] Mine reserves indicate the estimated future production of operating mines currently producing cleanable coal.

Recoverable reserves indicate the estimated deposits of cleanable coal which could be recovered by current mining technology (i.e., a recovery factor of 50%).

5.0 EVALUATION OF COSTS ASSOCIATED WITH THE COAL CLEANING PROCESS

Physical cleaning involves the separation of coal from waste products such as shale, pyrite, and roof-slate by utilizing differences in the physical properties of the materials. The practice of physically cleaning coal has existed for many years; however, until the current concern with SO_2 emission, the purpose has been to remove the so-called ash-forming shale which produces the major coal impurity. This material is removed to reduce transportation charges, the operating problems and associated expenses which this ash-forming material causes in practically all major uses of coal. Thus in 1968, 340 million tons, or about 65% of the total United States coal production, was physically cleaned to some degree. This percentage has remained relatively constant over the past ten years.

The physical removal of pyritic sulfur involves, first, crushing the coal to release the pyrite and, secondly, the physical separation of the pyrite from the coal. As the particle sizes become smaller, pyrite removal becomes more difficult and costly. In addition to greater coal-crushing costs, finer coal particles tend to retain more moisture and require additional thermal drying prior to shipping.

5.1 Cleaning Cost Factors

The costs associated with providing a ton of physically cleaned coal at the cleaning plant site (assumed located at mine) is the sum of the following:

- The cleaning plant amortization costs associated with each ton of deep-cleaned coal.
- The cleaning plant operating and maintenance costs associated with each ton of deep-cleaned coal. Operating costs include the disposal of the waste associated with the cleaning operations.
- The value of raw coal that is utilized in providing one ton of deep-cleaned coal.
- The share of state and local taxes (on cleaning plant) allocated against each ton of deep-cleaned coal.

5.2 Cleaning Plant Amortization Costs

General

Mechanical cleaning of coal is possible because of the differences between the physical properties of coal and those of its impurities. For the cleaning process to provide attractive pyrite removal benefits, it is necessary to select coals which possess characteristics amenable to pyrite removal and to have an appropriately designed cleaning plant.

The cost of a coal-cleaning plant can vary over a wide range. Plant cost basically depends on plant capacity and equipment composition assuming no undue site preparation charges. In general, for a given cleaning plant capacity, the higher the percent of coal fines and the finer the fines, the greater the cleaning plant costs. The increase in plant costs required to clean fine coal is due to both the greater capital equipment cost for cleaning the finer grinds of coal and the higher operating cost associated with drying the finer grinds of coal.

Data Considerations

Even though some cost data on several existing coal preparation plants is available, the value of such data is questionable. This cautious attitude concerning the utilization of past cost information is due to a number of reasons which include the following:

- Existing plants may not be representative of required deep-cleaning plant(s).
- The age of existing plants is not well defined.
- The questionable ability to extrapolate or project current plant costs from plants of different total makeup that were constructed in past years and under different economic conditions.
- The intricate details of existing plants are not well known (effectiveness and utilization restrictions).

These factors must be considered when using past plant/cost data to judge the reasonableness of newly acquired plant/cost estimates.

Capital Equipment Costs

Rather than depend on historical data of questionable value, the following coal-cleaning plant and cost information was obtained from engineers currently engaged in the design and construction of coal preparation plants.

- A well-designed, properly maintained cleaning plant will have a life expectancy of greater than 20 years.
- The current turn-key range of costs for a "deep"-cleaning coal plant are:

A. Minimum Plant

1. Input Capacity - 500 tons per hour and over.
2. Type of Plant - Minimal plant, top size crushing, one type mechanical sorting (e.g., Deister Table)
3. Cost - $2000 per ton hour capacity plus $1500-$2200 per ton hour drying capacity. In practice, one would only dry 50 to 60 percent of cleaned coal. Therefore, for minimum plant, the total costs (60% drying capacity) is $3320 per ton hour input coal capacity for plants with a minimum input capacity of 500 tons per hour.

B. Maximum Plant

1. Input Capacity - Figures derived for plant with 1400 tons per hour input capacity. The figures are believed fairly accurate for plants of 500 tons per hour input capacity and over.

2. Type of Plant - Very high quality cleaning plant. Plant performs crushing, screening (for various fractions), coarse washing, fine and coarse separation, froth flotation, recycling fractions, drying, and mixing.

3. Cost - $14,000 per ton hour input capacity. For plants of 500 tons per hour input capacity, the cost is estimated to be $15,000 per ton hour input capacity.

C. Medium Plant - This plant is believed to be in the class range required to clean those coals which are considered more readily cleanable.

1. Input Capacity - 500 tons per hour and over.

2. Type of Plant - Medium-high quality cleaning plant. Such a plant could include a combination of tables, cyclone separators, froth flotation units, filters, heat dryers, and a range of screen sizes.

3. Cost - For plants with input capacities of 500 tons per hour and over, plant costs will be essentially proportioned to capacity. The cost of such a plant with an input capacity of 500 tons per hour is estimated to be four million dollars complete. This is equivalent to $8,000 per ton hour input capacity.

Therefore, for plants with input capacities of 500 tons per hour and over, the estimated turn-key plant cost, including the cost of water treatment facilities, can range from $3320 to $15,000 per ton hour input capacity. This represents a cost ratio of essentially 4 1/2 to 1.

Capital Equipment Amortization

This study considers a range of possible plant costs. In addition, the variation in coal benefication costs due to different amortization periods and interest rates are also addressed.

Industrial quality coal-cleaning plants, when properly maintained, will undoubtedly have a life expectancy of greater than 20 years. Even so, the write-off or amortization period is usually based strictly on company fiscal policy as constrained or guided by Internal Revenue Service policies and regulations. Reference 16 contains guidelines for depreciable assets used by business in general. Under the category of Mining, defined to include the mining and quarrying of metallic and non-metallic materials plus the milling, benefication and other preparation of such materials, Reference 16 indicates a 10-year depreciation period.

It is believed that regardless of tax depreciation considerations, a mine operator would probably finance and amortize a coal preparation plant by means of an equal payment, self-liquidation loan or its equivalent. If the loan is payable with equal monthly installments, the total yearly amount per $1000 of loan for various amortization periods and interest rates is given in Figure 5-1.

Figure 5-1 may be used to obtain the cleaning plant yearly mortgage payment per ton coal input capacity for any type of cleaning plant. This is done simply by multiplying the amount indicated in Figure 5-1 by the new plant cost (i.e., per ton hour input capacity) divided by 1000. Thus the yearly mortgage payment for a plant costing $5000 per ton hour input capacity is five times the value indicated in Figure 5-1. Amortization tables and curves for plants of various costs are provided in Appendix III.

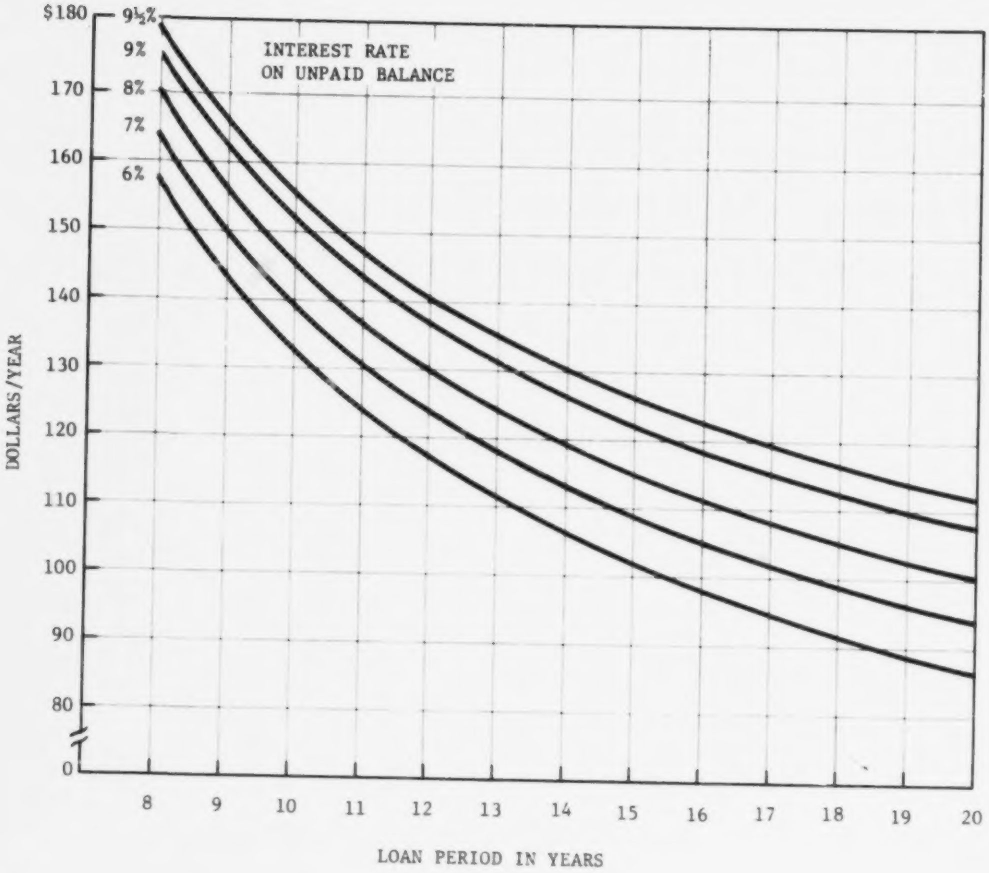

FIGURE 5-1
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $1,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

The yearly amortization costs for various amortization periods and interest rates (on the unpaid balance) have been provided in terms of plant cost per ton hour input capacity. The share of amortization cost attributable against each plant input ton of coal is merely the per ton hour input capacity yearly amortization costs divided by the yearly operating hours. The amortization cost per ton of deep-cleaned coal is simply the cost per plant ton input divided by the recovery (i.e., yield) expressed as a decimal.

The yearly operating hours of a cleaning plant as a function of plant utilization is indicated in Figure 5-2.

The per ton cleaned coal amortization values are given in Figure 5-3. These values are provided for a range of plant yields and utilization factors and are based on:

- a plant costing $8,000 per ton hor input capacity
- the IRS accepted 10-year amortization period
- an 8% interest (on unpaid balance)

Curves showing the relationships between amortization costs per ton of clean coal for various plant costs, interest rates, plant utilization figures, and recovery (yield) values are given in Appendix III. For all curves, the IRS accepted 10-year amortization period is employed.

5.3 Operation and Maintenance Costs

Operations and maintenance (O & M) costs are a function of:

- Coal Yield (i.e., weight percent of plant input coal that becomes clean coal)
- Cleaning plant labor requirements and rates

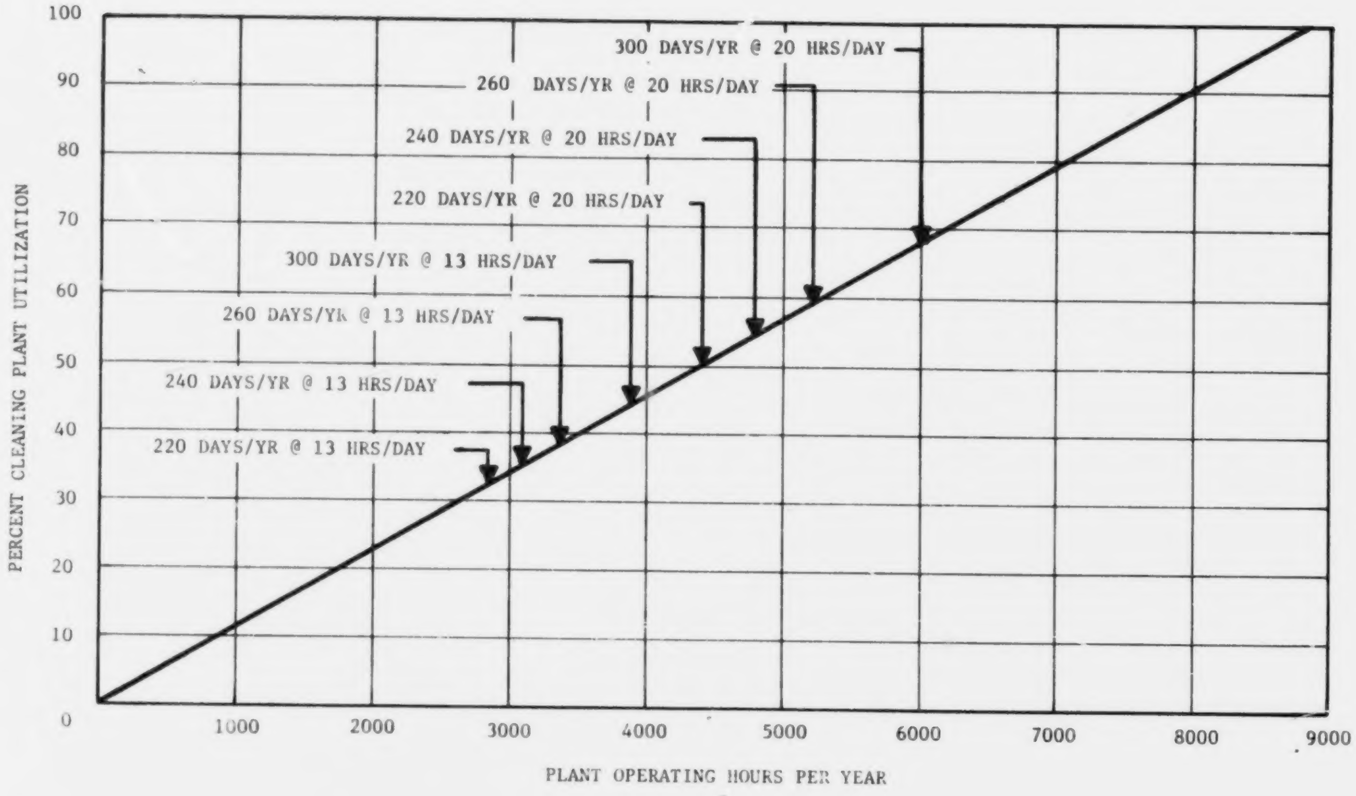

FIGURE 5-2
CLEANING PLANT UTILIZATION

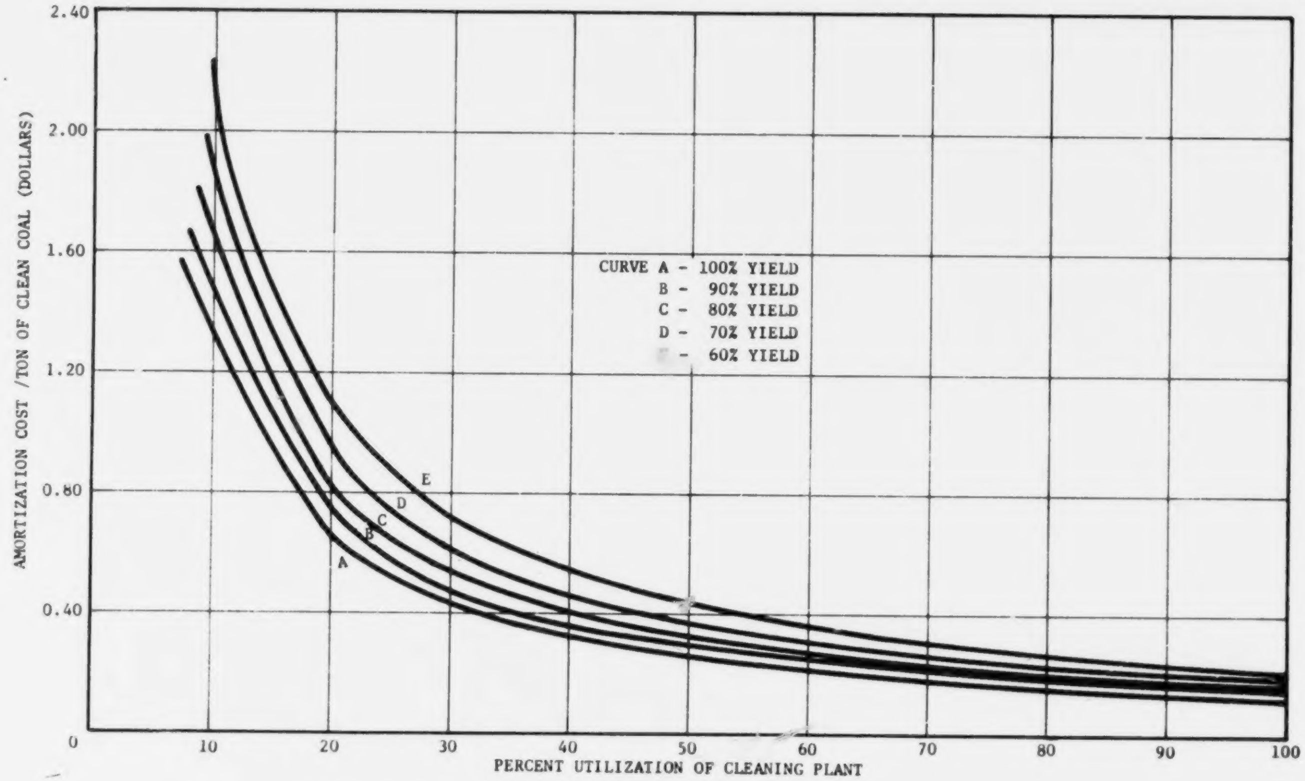

FIGURE 5-3
AMORTIZATION COST / TON CLEANED COAL
FOR:

PLANT COST - $8,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8 %. LOAN PERIOD - 10 YEARS

- Maintenance costs
- Cost of operating supplies
- Power costs
- Refuse handling and disposal costs

For a given plant, the through-put time required to produce a ton of "clean" coal depends on yield (i.e., the percentage of run-of-mine coal that ends up as cleaned coal). As an example, if a cleaning plant operating at input capacity takes X hours with a given yield to process or provide a ton of clean coal, then the same plant when operating at half the previous yield will take essentially 2X hours to provide a ton of clean coal. Therefore, the cleaning plant operating costs attributable to a ton of cleaned coal are (essentially) inversely proportioned to cleaning plant yield. In a like manner, maintenance, supply, and power costs will also be inversely proportional to yield. Refuse handling and disposal costs, however, do not follow this same relationship. This is evident from the fact that for 100% yield, refuse will not exist, and therefore refuse costs will be zero.

Operations and maintenance costs can therefore be considered to be composed of the sum of two cost categories. One cost category (i.e., sum of plant labor, maintenance, supplies, and power costs) being inversely proportional to yield and the other cost category (refuse handling and disposal costs) being directly proportional to the percent of refuse.

Operation and Maintenace Cost Data Considerations

Information on operations and maintenance (O & M) costs are available from various sources.[11,17,18] The basic problem is correlating or projecting past data to reflect current economic conditions. Difficulty in assessing the data is due to various degrees of uncertainty in the following:

- Year of initial data collection
- Plant type, total composition, and capacity
- Year(s) of cleaning plant construction and date of initial operations
- Special operating considerations (i.e., duty, maintenance, etc.)
- Management efficiency of operating company
- Total cost inclusions covered by available cost information

The most detailed information available on O & M costs is contained in Reference 11. Operations and maintenance cost information from the following sources were also examined and evaluated in arriving at anticipated present-day O & M cost values.

Reference 17 contains preparation costs (i.e., operating cost of coal-washing plant) for a 1500 tons/hour capacity plant, designed to produce both metallurgical coal and coal for utilities. The article defined O & M costs to be $0.253/ton of coal processed. According to the U.S. Bureau of Labor statistics the average hourly earnings for the first two months of 1970 for the bituminous coal industry are 143 percent of the average 1961 hourly earnings. Furthermore, the average hourly earnings for the bituminous coal industry were constant for 1959 through 1962. Therefore the 1961 O & M costs (i.e., $0.253/ton) corrected for 1970 becomes $0.362/ton of coal.

Table 5-1 on page 5-15 of Reference 18 contains operating costs obtained from extended records of a plant processing over one million tons of coal a year at 500 tons per hour with a plant reject of about 15 percent. Total labor, supplies, and power amounts to $0.30/ton. Since the information was published in 1968, it is assumed that the provided information was for the 1968 or at worst the 1967 time frame. Depreciation is listed and the sum of the previously mentioned $0.30/ton figure plus the depreciation associated with each tone is defined as the total cleaning costs. It is therefore assumed that preparation plant maintenance cost is included in the $0.30/ton figure. Correcting the $0.30/ton figure by the ratio of 1970 to 1967 average hourly earnings in the bituminous coal industry provides a 1970 O & M cost of $0.36/ton of plant processed coal. Thus, both References 17 and 18 result in the same adjusted 1970 O & M cost.

As previously indicated, Reference 11 contains information on a number of coal-cleaning plants. The provided data, associated with studies of six different cleaning plants, have been examined as a basis for developing current cleaning plant O & M costs per ton of processed coal. These case studies, updated to 1970 (February) conditions, are provided in Appendix IV.

The development of updated (to February 1970) O & M costs indicates that for examined coal-cleaning plants of the general type, class, and costs indicated by practicing engineers, the spread of O & M costs are small. Figure 5-4 indicates the O & M associated with plants addressed in Cases I, V, and VI of Appendix IV. These three plants are believed representative of the expected composition and costs of plants that will be required to clean "readily cleanable" coals. In addition, an average curve of the two extreme cases (i.e., Cases V and VI) is provided. As indicated, the O & M costs for all three cases differ from the average curve (of the extreme cases) by not more than 7¢ for a 90% yield, by not more than 10¢ for an 80% yield, and not more than 12¢ for a 70% yield. This spread is not unreasonable and could well be attributed to differences in plant conditions, plant composition, and management philosophy.

For this effort, the values associated with the average curve will be used. The deviations of 7,10, and 12 cents will be considered to be the uncertainty or maximum possible variation in O & M costs (i.e., for the associated yields).

5.4 Value of Raw Coal Required Per Ton of Cleaned Coal

Raw coal value is defined as the operator's break-even cost for providing a ton of raw coal input to the deep-cleaning plant. Such cost would include all appropriate expenses (e.g., royalties, labor and equipment, fair share of insurance, taxes, and mine development costs).

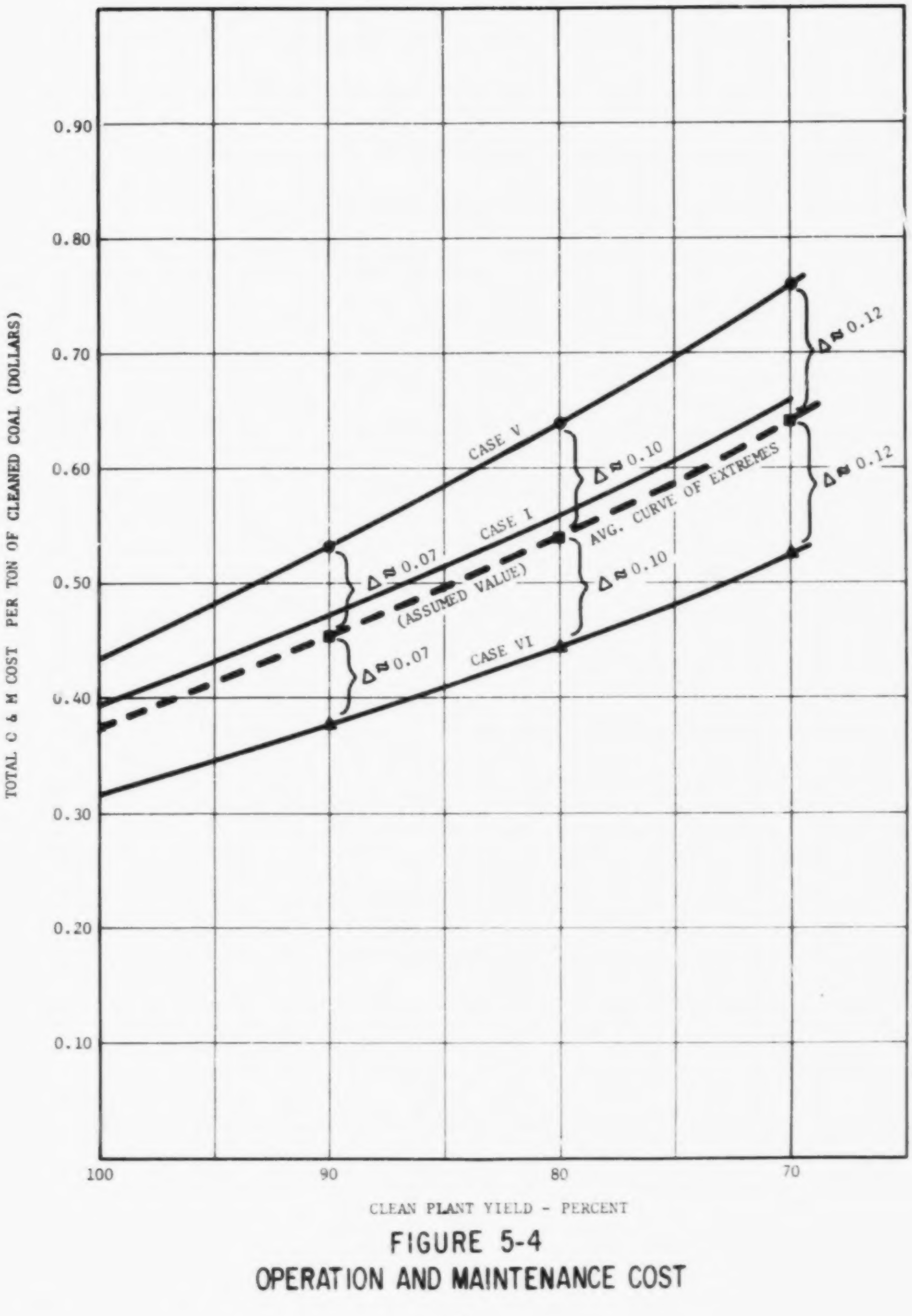

FIGURE 5-4
OPERATION AND MAINTENANCE COST

Since coal is lost in the cleaning process, it takes more than one ton of raw coal to provide a ton of cleaned coal. The value of raw coal that is used to produce a ton of cleaned coal is simply equal to the per ton raw coal value divided by the cleaning plant yield expressed as a decimal. Curves indicating the value of raw coal required to produce a ton of clean coal are given in Figure 5-5. The "additional" raw coal value to provide one ton of cleaned coal is the value of the raw coal lost during the cleaning process and is equal to the raw coal value required to produce a ton of cleaned coal less the per ton raw coal value.

5.5 State and Local Taxes Allocated Against Each Ton of Cleaned Coal

Each ton of cleaned coal must support its share of cleaning plant state and local taxes. For this effort, a tax level of 2% of the initial cleaning plant value is employed. The tax load attributable against each ton of deep-cleaned coal (assuming cleaning plant operates at capacity) is:

$$\text{Tax/ton clean coal} = \frac{\text{Cleaning plant cost per ton hour input capacity} \times 0.02}{\text{Operating hours per year} \times \text{yield (decimal value)}}$$

$$= \frac{\text{Cleaning plant cost per ton hour input capacity} \times 0.02}{8760 \times \text{utilization (decimal value)} \times \text{yield (decimal value)}}$$

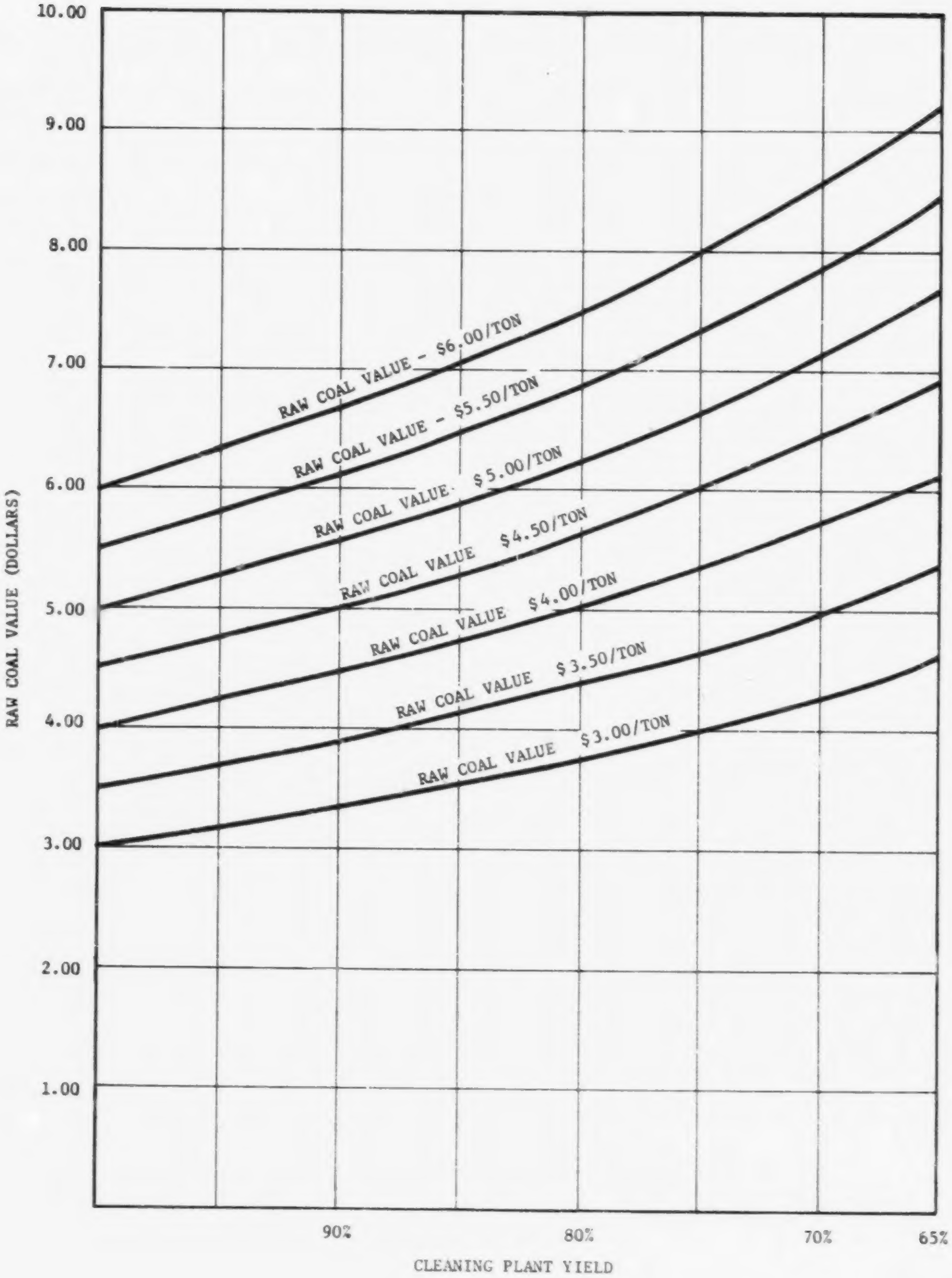

FIGURE 5-5
VALUE OF RAW COAL REQUIRED TO PRODUCE A TON OF CLEANED COAL

Thus, the tax allocated against each ton of cleaned coal from a cleaning plant costing \$8000 per ton hour input capacity is:

$$\text{Tax/ton clean coal} = \frac{\$160}{8760 \times \text{utilization (decimal value)} \times \text{yield (decimal value)}}$$

Figure 5-6 indicates the tax burden/ton of clean coal for a plant costing \$8,000 per ton hour input capacity. The tax (Figure 5-6) is a function plant utilization and plant yield.

5.6 Precipitator Economics

For a 200 Mw steam generating plant that burns 2% sulfur, 12% ash, 12,000 BTU/pound fuel, precipitator costs have been estimated to be \$3250 Mw capacity.[24] For a 1% sulfur content fuel, precipitator costs have been estimated to be \$4240 per Mw capacity.[25]

With a precipitator 70% utilization factor coupled with a requirement of 0.45 tons of coal to produce one MwHr of energy, the difference in amortization cost amounts to 3.5¢ per ton of coal burned for a 20 year, 8% write-off, and 5.07¢ per ton of coal burned for a 10 year, 8% write-off. This is a second order economic factor and is not included in this general economic evaluation of physically desulfurized coal.

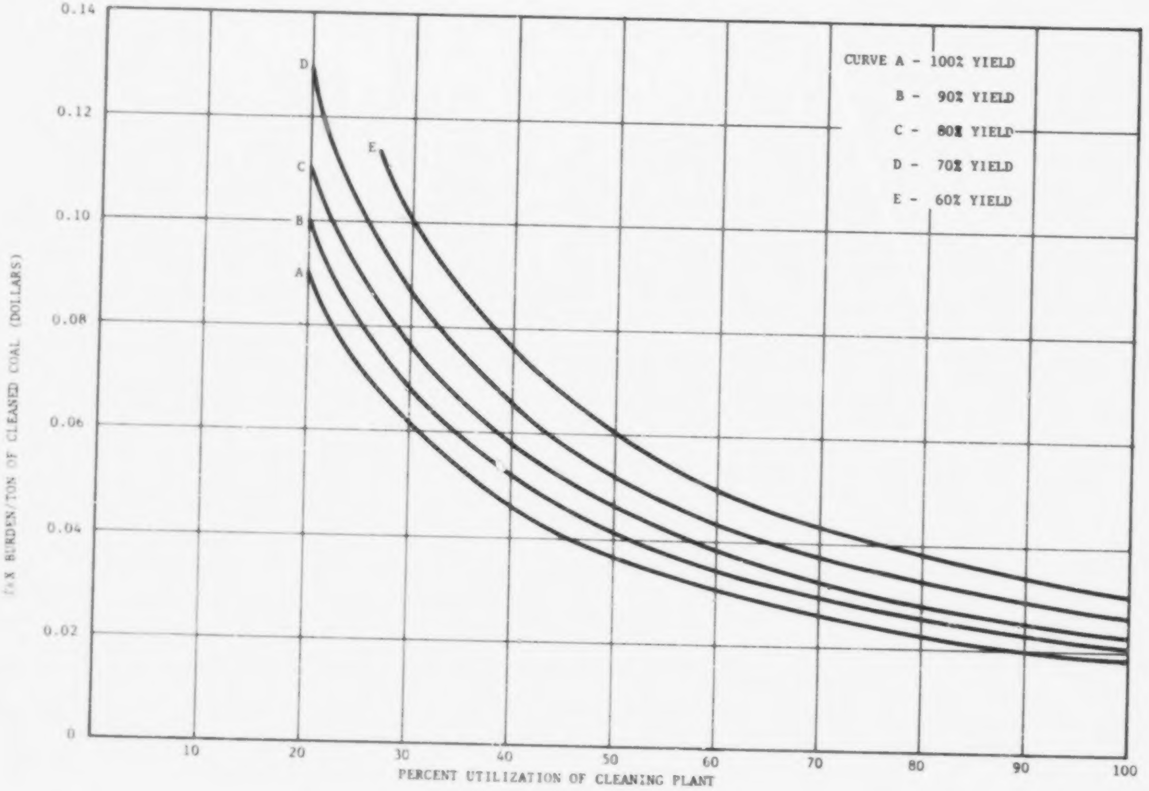

FIGURE 5-6
TAX BURDEN/TON OF CLEANED COAL
FOR:
PLANT COST - $8,000 PER TON HOUR INPUT CAPACITY
AND TAX RATE OF 2%

6.0 EVALUATION OF ECONOMIC BENEFITS ASSOCIATED WITH THE USE OF CLEANED COAL

6.1 Economic Benefit Factors

The readily identifiable monetary benefits attributable to a power plant burning cleaned coal are as follows:

- Cleaned coal has a higher heat content per ton than the raw coal from which it is produced. Therefore, less cleaned coal will be required to provide a given heat content value.
- Less cleaned (higher heat content) coal need be shipped for a given overall heat content value. Therefore, the cost of shipping will be less.
- Cleaning reduces the ash content of coal. The ash requiring disposal by the utility will be less due both to the lower ash content per ton burned and to the fact that fewer tons of coal will be burned (i.e., for a given heat content value).
- Cleaning often reduces the hardness of the coal. The reduction in hardness is difficult to quantify. Even so, since less coal need be ground for a given heat content value, the grinding costs will decrease.
- Mine operators pay 40 cents to a welfare fund for each ton of coal shipped from the mine. Cleaning, by raising the heat content of coal, will cause a decrease in the number of tons shipped (for a given heat content). Thereby a saving equal to 40 cents times the reduction in shipped tonnage will be attained.

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. There is evidence that savings in power plant maintenance costs will be obtained by using coal with reduced sulfur and ash content. Thus, since "deep"-cleaning reduces the ash and sulfur content of coal, lower power plant maintenance cost may result. In addition, for a given heat content value less tons of "deep"-cleaned coal need be handled by the power plant. Therefore, power plant units which are tonnage (utilization) limited will have an increased operational life.

6.2 Increased Heat Content

An economic benefit readily identifiable to the purchaser of cleaned coal is equivalent to the F.O.B. raw coal price (i.e. price of unprepared coal) times the fractional increase in heat value of the cleaned coal over that of the raw coal. This is the equivalent F.O.B. raw coal price associated with the amount of coal that provides the equivalent heat increase.

If raw coal has an initial heat content of $\underline{A}$ per ton and if upon deep-cleaning the heat content decimal increase is $\underline{x}$, then the deep-cleaned coal will have a heat content of $A\ (1 + x)$ per ton. The increase over the initial value is $A\ (1 + x)-A$ or $\underline{Ax}$ per ton. The fractional amount of cleaned coal that need not be shipped (i.e., the amount that offsets the heat content increase) is $Ax/A\ (1 + x)$ or $\frac{x}{1 + x}$. For the purposes of this study the factor $\frac{x}{1 + x}$ shall be termed the multiplier factor $\underline{K}$ Therefore the per cleaned ton benefit gained, a function of the raw coal F.O.B. price and the increase in heat content, is equal to the F.O.B. raw coal cost (per ton) times $\frac{x}{1 + x}$.

Whereas the raw coal value (i.e., the cost to the operator) is assumed to run between \$3.00 and \$6.00 a ton, the raw coal F.O.B. price (i.e., the selling price) is assumed to run between \$4.00 and \$8.00 per ton. These values are based on conditions existing during the first six months of 1970. Figure 6-1 indicates the benefit gained as a function of the raw coal F.O.B. price and the increase (up to 28%) in heat content over the initial value.

6.3 Savings in Coal Transport Costs

Since cleaning increases the heat content of coal, less cleaned coal need be shipped to supply a given heat value. The amount of transport savings attainable by cleaning is a function of the increase in the coal heat content and the coal shipping costs.

The effective transport saving per ton cleaned coal is equal to

T.C. x K

where:

T.C. = Transportation Cost per ton of coal

K = the multiplier factor $\frac{x}{1+x}$

Figure 6-2 indicates the multiplier factor K as a function of heat content increase.

Coal is currently shipped by train, waterway carrier, and truck. The transport mode or combination of modes employed in a given situation is usually determined by overall economic considerations. Considerations have been given to shipping costs associated with the following:

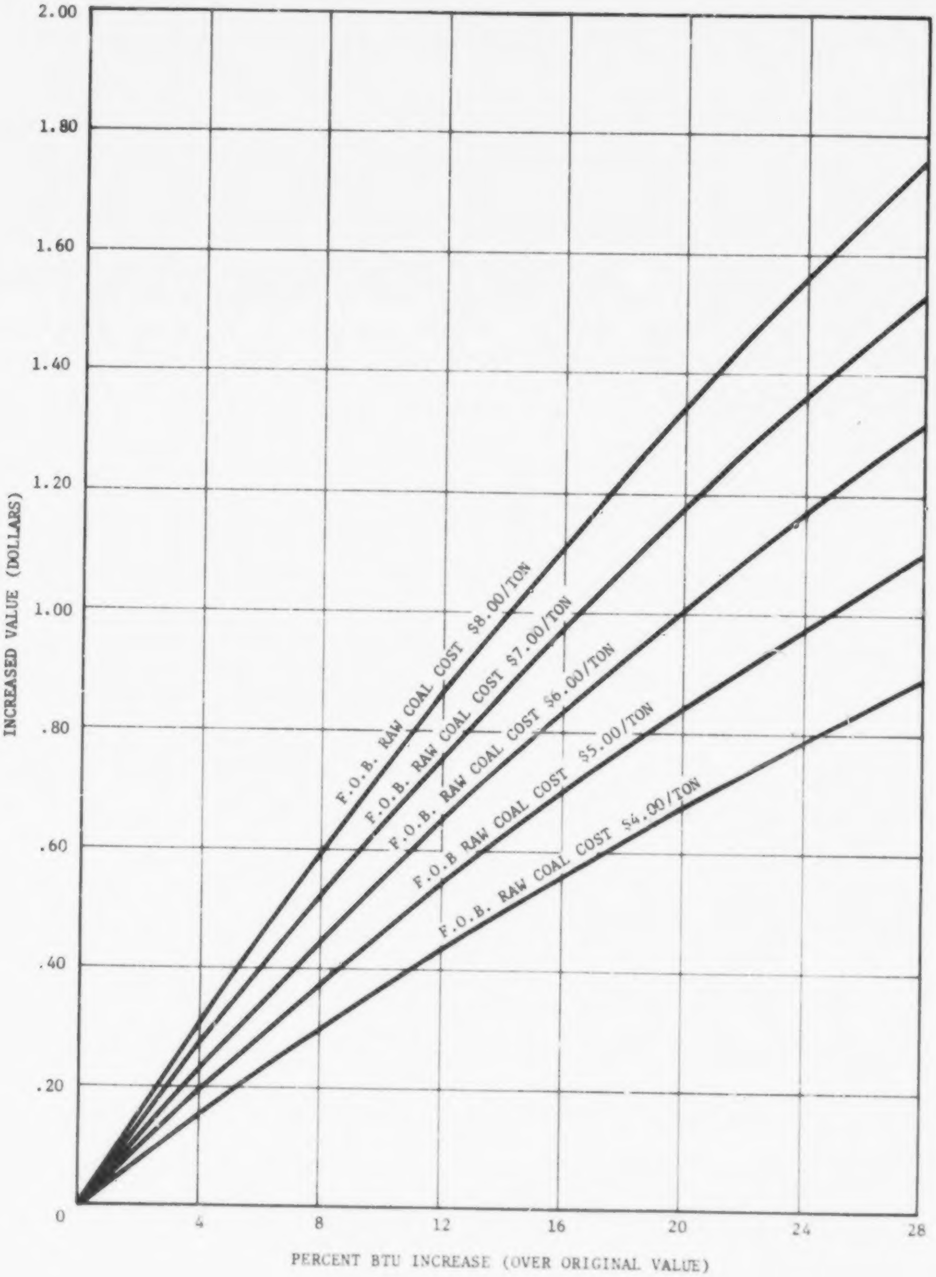

FIGURE 6-1
ADDED COAL VALUE DUE TO INCREASE IN HEAT CONTENT

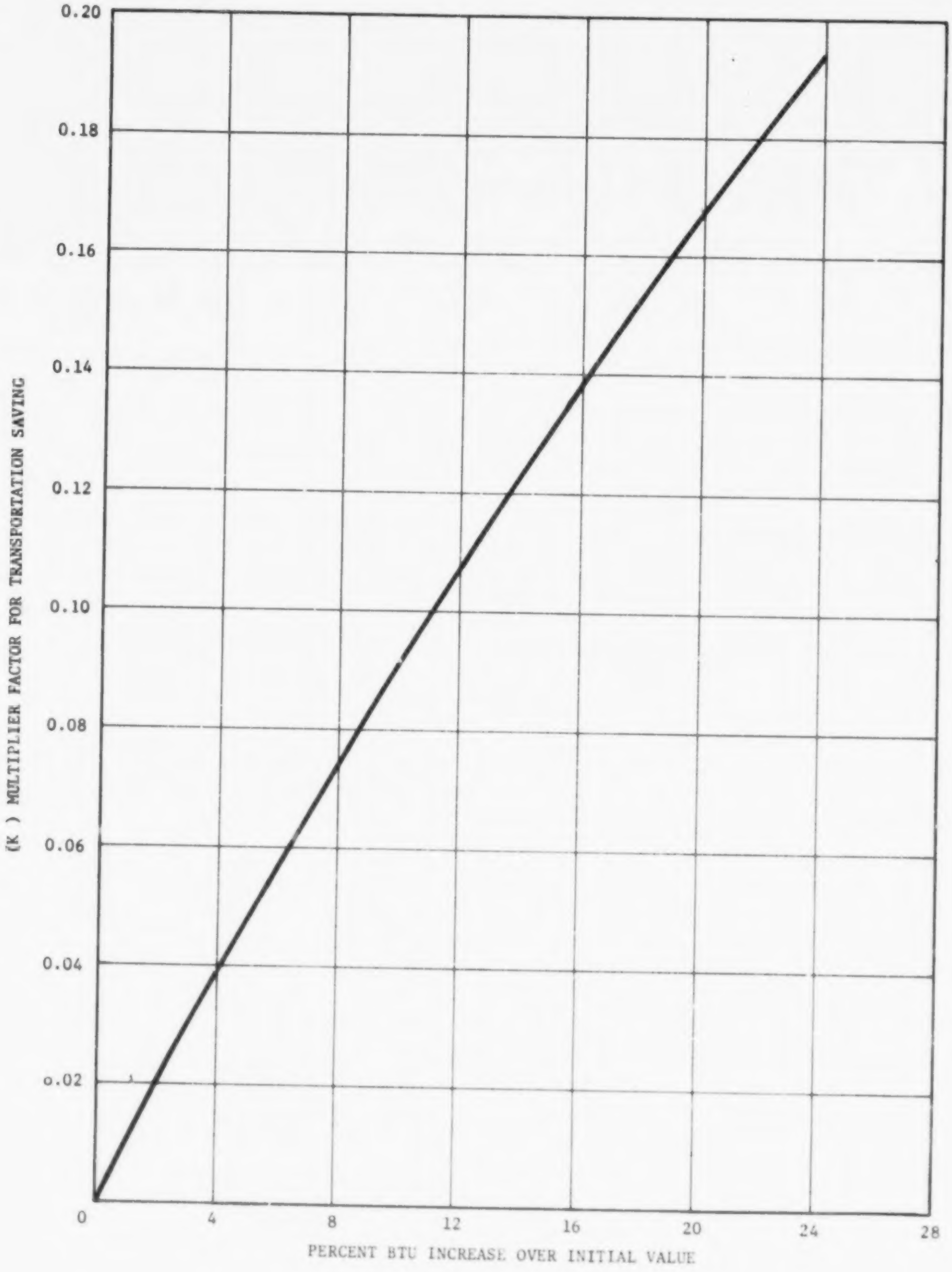

FIGURE 6-2
EFFECTIVE SAVINGS IN TRANSPORT COST DUE TO INCREASE IN COAL HEAT CONTENT (EQUALS SHIPPING COST XK)

- Railroad bulk coal shipping tariffs
- Unit train costs
- Truck costs
- Barge costs

Railroad Bulk Tariffs

Railroad bulk tariff rates apply to volume shipments usually with restrictions on the number of sources and the number of destination points. For this effort we have considered bulk tariff rates applicable to the locations and carriers considered. These have been designated "single car," rate A, rate B, rate C, and other individually defined bulk rates (when applicable). Rates A, B, and C may be defined as follows:

- Rate A — 7000 ton train, all coal originating from not more than two origins using same assembly point
- Rate B — 7000 ton train, coal originating from three or more origins using same assembly point
- Rate C — Smaller train, 4500 tons from one or more origins using same assembly point

Unit Trains

The unit train is a management technique that permits efficient planning through long-range contractual commitment of producer and consumer and dedication of the equipment. Specifically, a unit train consists of a dedicated set of haulage equipment loaded at one origin, unloaded at one destination each trip, and moving in both directions on a pre-determined schedule. Although the origin and destination are not necessarily the same for each trip, the shipment is never split for any trip.[19]

In terms of the tariff, or freight rate, a unit train is not a unit train until so designated by the carrier. Thus, the success of a unit train depends on cooperation between shipper, carrier, and consumer. In fixing tariff rates, the lowest cost usually is realized when a unit train is limited to a single-line haul. When more than one carrier is involved, additional capital cost and additional operating costs are reflected in the tariff rates. The tariff rates specify the haulage cost to the consumer on a net ton basis. Three parties, the railroad, producer, and the consumer, must negotiate the conditions and the rates (coal and transport) for unit train service.[19]

Reference 19, dated 1970 and published by the Bureau of Mines, contains a number of case studies on unit train transport cost and conditions. Information in Table 6-1 was obtained from this study.

For shipping in railroad owned or railroad leased cars, the cost of shipping varied between 0.54¢ and 0.78¢ per ton mile. Reference 20 confirmed the representativeness of the above-cited values. For this study a range of unit train haulage values are considered. Values between 0.5¢ and 1.0¢ per ton mile should bracket all considered unit train haulage cost. For non-unit train haulage, rates provided by the railroads are utilized. As previously implied, for this investigation it is assumed that all rolling stock is owned by the railroads. Of course it should be realized that if rolling stock (cars) are supplied by either the producer or consumer, haulage rates payable to the railroads will be less. Even so, real haulage costs must consider the value of the provided rolling stock.

Reference 20 also clearly indicates that the difference in transportation costs between raw run-of-mine bituminous coal and cleaned or prepared bituminous coal in average revenue per ton mile for the same territorial movements is less than one percent.

Barge Shipment of Coal

Excluding the Great Lakes, the United States has over twenty-five thousand miles of commercially navigable inland waterways. Reference 21 indicated that in 1968 almost 114 million tons of bituminous coal and lignite were transported on the inland waterways of the United States (exclusive of the Great Lakes).

TABLE 6-1

UNIT TRAIN CASE STUDIES[19]

MINE LOCATION	PREPARATION	HAULAGE DISTANCE (ONE WAY/MI)	OWNERSHIP OF CARS	MINIMUM TONS PER SHIPMENT	HAULAGE COST PER TON MILE (CENTS)
Illinois	Clean	279	Consumer	12,500	0.54
W. Va.	Clean	450	RR	7,000	0.78
Illinois	Clean	306	Consumer	12,600	0.44
Illinois	Blended	354	Consumer	10,200	0.52
Penna.	Clean	180	Consumer	10,500	0.83
Illinois	Raw	130	RR	7,000	0.77
Ky.	Raw	333	RR	7,000	0.54
Tenn.	Clean	457	Leased by Producer	10,000	0.38
Ky.	Raw	129	Leased by Producer	7,500	0.78
Ohio	Raw	317	Leased by Producer	8,200	0.52

Barge towing costs used for this effort are indicated by Figure 6-3 and are based on information in Reference 18 as updated by information obtained from the U. S. Bureau of Labor Statistics.

Truck Shipment

Reference 22 states that in 1967 over 47 million tons of coal were shipped by truck on public highways. Some trucks have capacities over 100 tons, but because of weight limitation on highways and bridges are used only on mine roads. The trucks that haul coal directly to the final destination carry 10 to 20 tons, and the trips usually are short, rarely exceeding 100 miles. The transportation cost for these short hauls are estimated to be between 3.0 and 7.0 cents per ton/mile, depending on distance, traffic, load factor, and load/unload conditions. Average trucking cost used in this study are indicated by Figure 6-4 and were again obtained from Reference 18 as updated by information from the U. S. Bureau of Labor Statistics.

The information in Table 6-2 was obtained from Reference 22 and indicates bituminous coal quantities shipped by various modes of transportation during the 1967 calendar year.

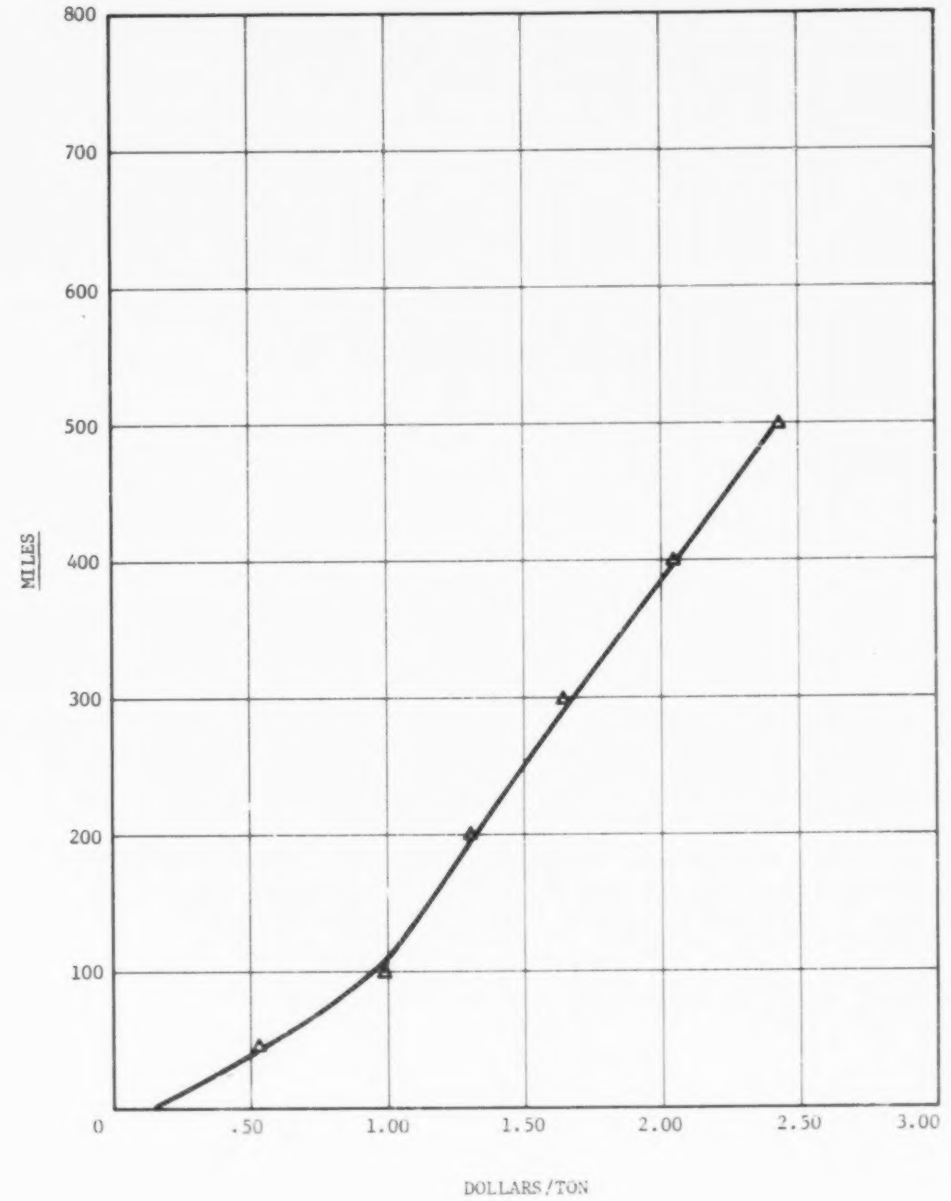

FIGURE 6-3
ESTIMATED 1970 BARGE TOWING COSTS-
OHIO RIVER AND TRIBUTARIES

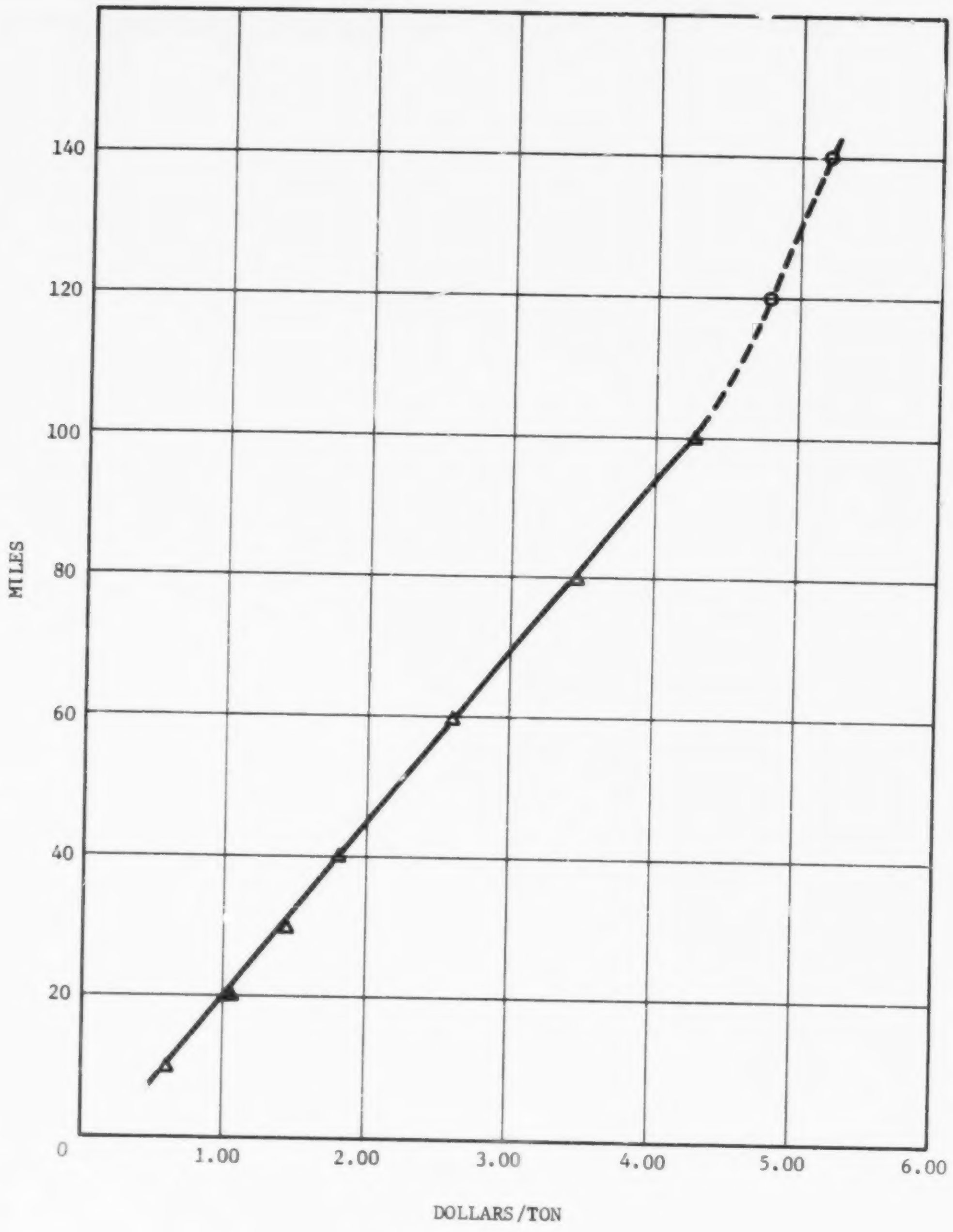

FIGURE 6-4
ESTIMATED 1970 HAULAGE COSTS - PUBLIC HIGHWAY TRUCKING

TABLE 6-2

MODES OF COAL TRANSPORTATION
(1967)

MODE	QUANTITY SHIPPED
Coal loaded for shipment by railroads (Includes class I, II, and private)	404,525,000 tons
Revenue freight handled by class 1 railroads (originated-net tons)	376,706,934 tons
Unit train handling	102,330,000 tons
Domestic inland water movement	98,055,622 tons
Truck shipment	47,597,000 tons

Figure 6-5 summarizes the general trends in transportation per ton of coal for the various modes and conditions of transportation discussed.

6.4 Savings in Ash Disposal Costs

Savings in ash disposal costs will be realized when cleaned coal is used (i.e., as opposed to non-prepared coal). This saving is due to the following two reasons:

- Cleaning lowers the ash content of coal
- The heat content is raised by the "deep"-cleaning process

Therefore, less coal needs to be burned for a given heat content value.

The effective saving in ash disposal cost per ton of cleaned coal burned is equal to the ash disposal saving per ton of coal burned, resulting from lower ash content, times a multiplier factor to account for the higher heat content of the cleaned coal. This multiplier factor is $(1 + x)$ where (x) is the fractional increase in heat content. Assuming that a (x) fractional increase in heat content results from a (x) fractional reduction in ash content, then the total effective ash disposal savings per ton of coal burned (due to cleaning) is equal to the disposal cost per ton of ash times $x(1 + x)$.

Figure 6-6 indicates the ash handling and disposal savings per ton of coal burned as a function of ash reduction when the ash handling and disposal cost is $1.50 or $2.00 per ton. These general values are considered representative of current electric utility experience.

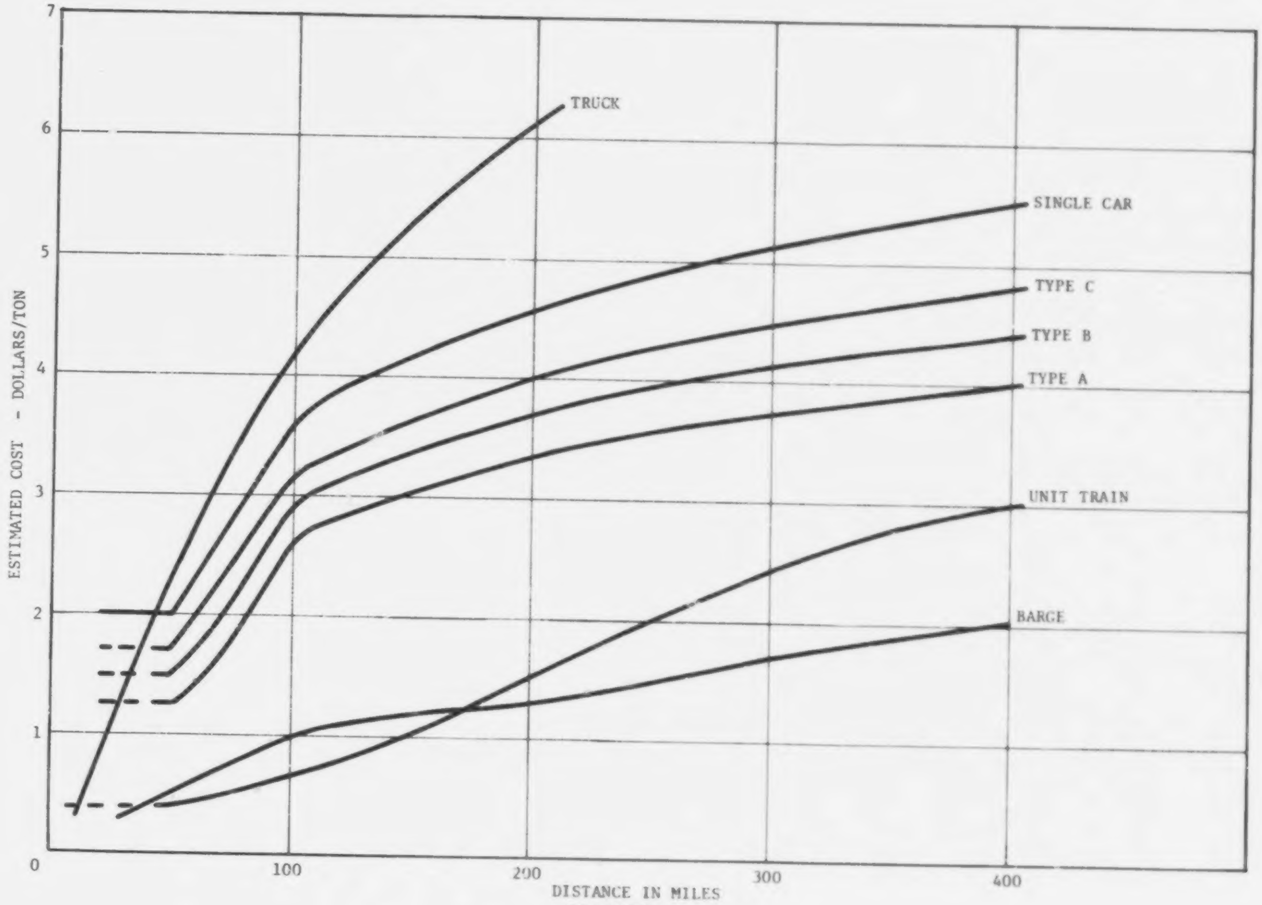

FIGURE 6-5
COAL TRANSPORTATION COSTS
GENERAL TREND, MODE VS. DISTANCE

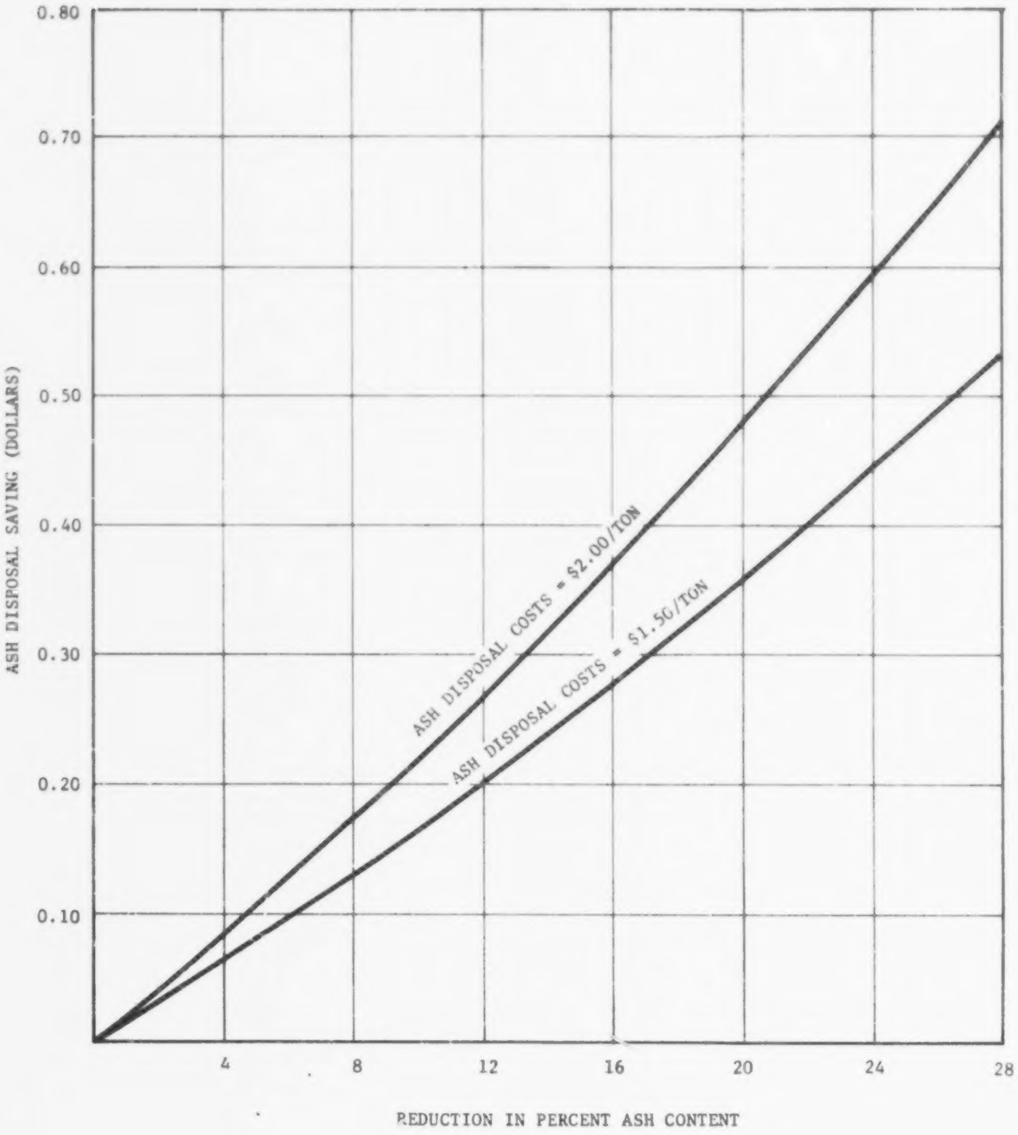

FIGURE 6-6
ASH DISPOSAL SAVING PER TON OF COAL BURNED

6.5 Savings in Coal Grinding Costs

Evidence exists that in some cases lower pyrite content coal is easier to grind. However, this effect does not appear to be universal; and the effect on grinding cost is not always discernable. Battelle, TVA, and several utility companies estimate that it costs \$0.25 to grind one ton of coal. This is considered the total operation and maintenance cost.

The identifiable saving associated with cleaning coal results from the increased heat content of a ton of cleaned coal. Therefore, less coal need be ground to supply a given heat value. The cost savings relationship (on a per ton basis) is:

Cost Savings = \$0.25 times K, where

K = the multiplier factor $\frac{x}{1 + x}$

As an example, consider that cleaning raises the heat content of coal by 10%, e.g. from 10,000 to 11,000 BTU's per pound. In this case, the fractional decrease in the amount of coal that would compensate for the increase in heat content is $\frac{0.1}{1 + 0.1} = \frac{0.1}{1.1}$. The saving would be (on an equivalent per ton basis) equal to $0.25 \times \frac{0.1}{1.1}$ or \$0.0227 for each ton of "deep"-cleaned coal burned.

The savings in grinding cost as a function of increase in heat content is given in Figure 6-7.

6.6 Savings in Payment to Welfare Fund

The mine operator pays forty cents to the welfare fund for each ton of coal shipped to a consumer. If, by cleaning, the heat content

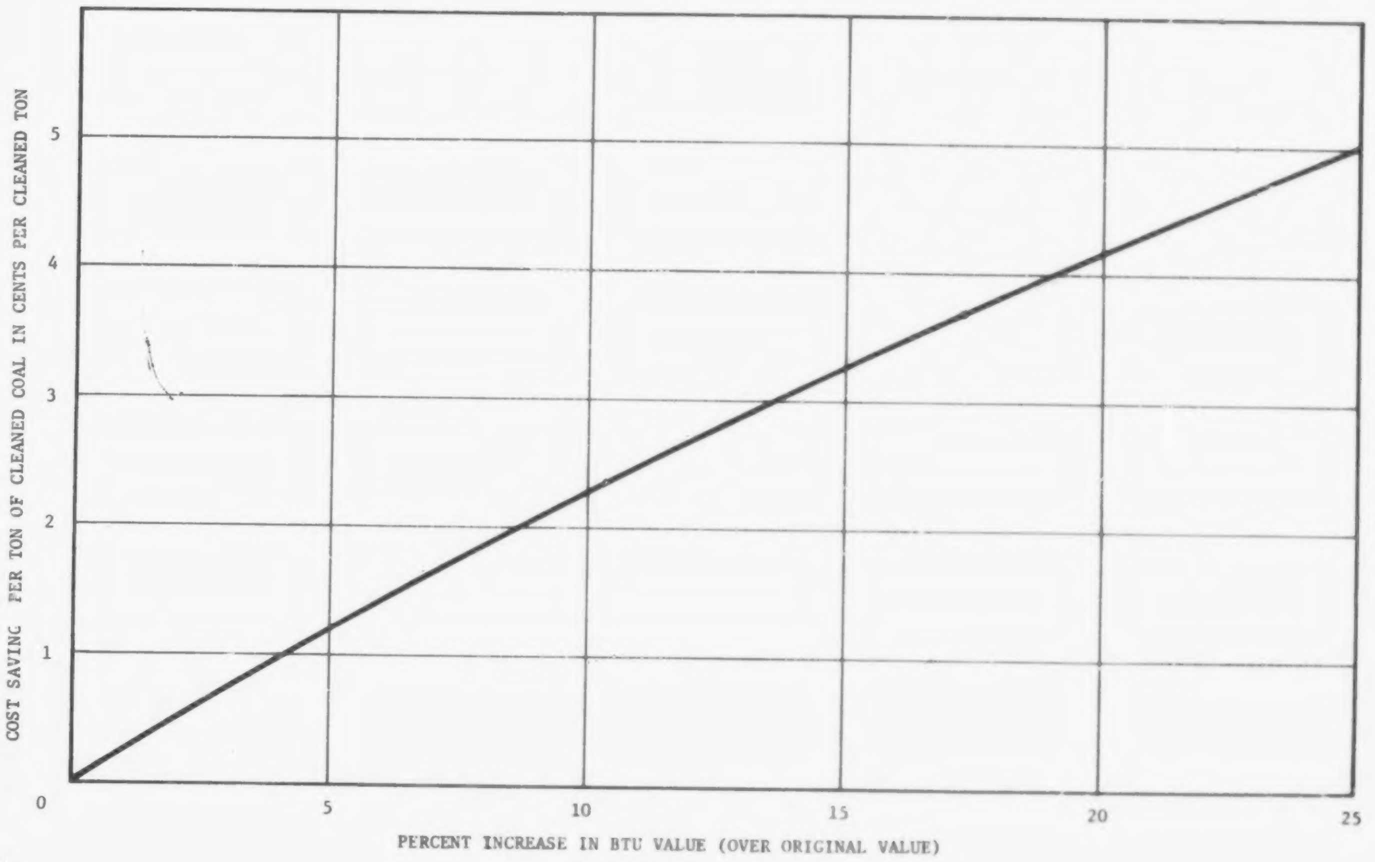

FIGURE 6-7
GRINDING COST SAVING

is raised by a decimal increase of x, then to satisfy a given heat content demand $\frac{x}{1 + x}$ less coal need be shipped. The savings attributable to each ton of cleaned coal is then equal to $0.40 times K. Figure 6-8 indicates this saving as a function of heat content increase.

6.7 Maintenance Savings

Only two data sources have been identified in which operating conditions and collected data are such as to permit a judgement relating sulfur and ash content in coal to power plant maintenance costs. The two sets of data are for identical steam power plants which burn coals of different ash and sulfur contents.[23] The available data, however, do not permit firm assessments of variations in maintenance savings with variations in coal ash and sulfur contents.

These data are derived from two TVA generating boiler units each having 200 Mw generating capacity. These two units, both pulverized coal fired boilers, were built in the mid 1950's. Information on the average proximate analysis of coal burned at the two plants and coal associated maintenance costs for the two plants are given in Tables 6-3 and 6-4.[23] The data cover approximately 74 million tons of consumed coal. The available maintenance data with conclusions indicates:

- Maintenance costs for all the items listed in Table 6-4 are greater for the plant burning the higher ash and sulfur coal.

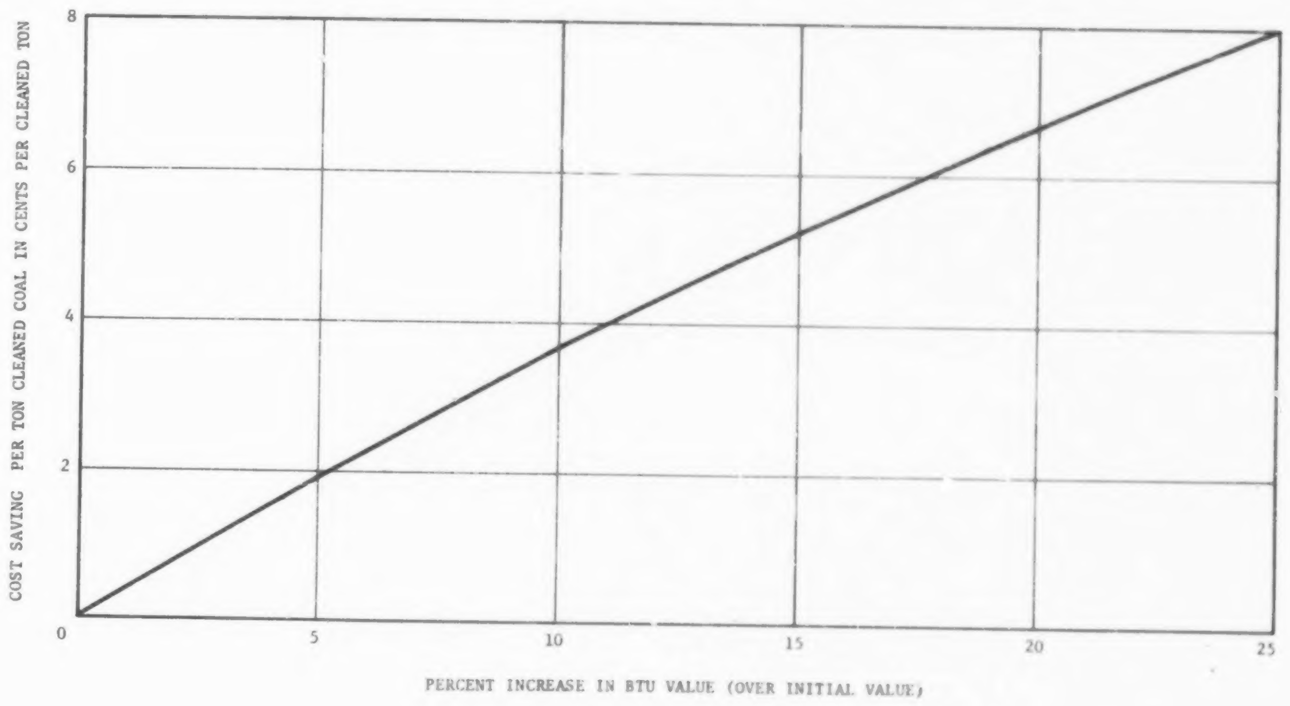

FIGURE 6-8
WELFARE FUND SAVING

TABLE 6-3

AVERAGE PROXIMATE ANALYSIS OF AS BURNED COALS UTILIZED IN TWO IDENTICAL STEAM-ELECTRIC PLANTS [23]

	PLANT A	PLANT B
Moisture	4.9%	5.1%
Volatile Matter	32.4%	33.8%
Fixed Carbon	52.1%	47.7%
Ash	10.8%	13.4%
Sulfur	1.0%	2.7%
BTU Content (per pound)	12,680	12,053

TABLE 6-4

COMPARISON OF MAINTENANCE COSTS WHEN BURNING DIFFERENT ASH AND SULFUR CONTENT COALS IN IDENTICAL POWER PLANTS [23]

ITEMS WITH COAL ASSOCIATED MAINTENANCE COSTS	MAINTENANCE COSTS (Cents per Ton)	
	PLANT A	PLANT B
Primary Coal Crushing	0.34	0.76
Coal Conveyers	1.24	1.65
Boilers	3.72	6.42
Soot Blowers	0.80	2.55
Pulverizers	3.45	5.38
Burners	0.80	1.59
Air Preheaters	0.41	0.62
Bottom Ash Hoppers	0.55	1.73
Fly-Ash Collectors	0.80	1.52
Ash Disposal System	2.70	3.60
Coal Piping	0.80	1.42
Totals	15.61	27.24

(difference = 11.63 cents per ton

. The difference in maintenance cost amounts to 11.63¢ per ton of coal. This difference in maintenance cost for the two units is almost two to one. This difference is not accounted for by the ≈5% difference in heat content value between the two coals.

As indicated in Table 6-3, the average difference in ash content of the coals consumed by the two plants was 2.6% and the average difference in sulfur content was 1.7%. No information is available on maintenance costs with variations in ash and sulfur content for a given plant. However, these results suggest that maintenance savings of up to 20 cents per ton of coal burned may be expected in steam plants capable of substituting low sulfur and low ash coal for their current steam coal.

For the purposes of this study, it is assumed that the maintenance savings indicated in Table 6-5 will be obtained for the listed reductions in total ash and sulfur contents. The assumed savings appear reasonable (i.e., conservative) when compared with available TVA data.

TABLE 6-5

ASSUMED MAINTENANCE SAVINGS AS A FUNCTION OF ASH AND SULFUR REDUCTION

Total Additive Reduction in Ash and Sulfur	Maintenance Savings per Ton of Coal Burned
15% and over	$0.20
12% to 15%	0.18
9% to 12%	0.16
7% to 9%	0.14
5% to 7%	0.12
3% to 5%	0.10
2% to 3%	0.08

7.0 COST/BENEFIT ANALYSIS

7.1 Introduction

As part of this effort, NAPCA supplied twenty-one coal source/user destination pairs for evaluating the economic impact of "deep"-cleaned coal on stationary power sources. For each pair, the mine location, the consuming city, the percent ash and sulfur in the raw coal; and the yield, percent ash and sulfur in the cleaned coal were specified by NAPCA. In order to more fully cover the range of potential clean coal source/user combinations in the Eastern United States, additional pairs were chosen by MITRE and included in this study.

Table 7-1 describes these thirty source/destination pairs with the specified raw coal ash and sulfur contents, ash and sulfur contents after cleaning, and transportation factors. For each source/destination pair, Table 7-1 lists the anticipated carrier, the distance between coal source and user, together with the shipping cost(s) for appropriate mode(s) of transportation. Finally, Table 7-1 indicates the percent transportation saving (i.e., K expressed as a percentage) for each source/destination pair, and the effective transportation saving per ton of clean coal for each considered transportation service.

Figures 7-1 through 7-4 are maps indicating the selected source/destination pairs along with the probable transportation route for

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TABLE 7-1

SOURCE/DESTINATION PAIRS WITH RELATED INFORMATION

	RAW COAL		CLEAN COAL						SHIPPING COST $/TON				SAVING PER TON				SAVING WITH UNIT TRAIN SERVICE PER TON		
									RAIL SERVICE										
	% ASH	% T.S.	% ASH	% T.S.	CARRIER	APPROX. MI.	% BTU INCR.	% TRANS-PORT SAVG	SINGLE CAR	A	B	C	SINGLE CAR	A	B	C	@0.5¢ PER TON-MI	@0.8¢ PER TON-MI	@1.0¢ PER TON-MI
1a ALLEGANY COUNTY, MD. TO BALTIMORE	20.3	1.13	13.1	1.06	W. M.	160	7.25	6.725	5.17	3.79	4.06	4.48	34.7¢	25.4¢	27.2¢	30.1¢	5.4¢	8.6¢	10.8¢
1b ALLEGANY COUNTY, MD. TO WASH.,D.C.					B & O	146			5.17 (ABOVE VALUES ASSUMED BASED ON TARIFFS FOR RELATED CASES)	3.79	4.06	4.48	34.7¢	25.4¢	27.2¢	30.1¢	4.9¢	7.8¢	9.8¢
2 GARRETT COUNTY, MD. TO BALTIMORE	12.0	0.96	8.0	0.64	B & O	215	4.03	3.855	5.17	3.79	4.06	4.48	19.8¢	14.6¢	15.6¢	17.3¢	4.2¢	6.6¢	8.3¢
3 GARRETT COUNTY, MD. TO WASH.,D.C.	14.4	1.14	9.6	0.82	B & O	200	4.85	4.585	5.17	3.79	4.06	4.48	23.7¢	17.4¢	18.6¢	20.6¢	4.6¢	7.4¢	9.2¢
4 ALLEGANY COUNTY, MD. TO BALTIMORE	11.9	1.13	10.6	1.07	B & O	160	1.35	1.285	5.17	3.79	4.06	4.88	6.6¢	4.8¢	5.2¢	6.3¢	1.0¢	1.6¢	2.05¢
5 COLUMBIANA COUNTY, OHIO TO CLEVELAND	10.39	2.34	4.68	0.62	PC	105	5.715	5.47	3.96					21.4¢			2.86¢	4.6¢	5.7¢
6 COLUMBIANA COUNTY, OHIO TO YOUNGSTOWN	9.32	2.39	1.90	0.99	TRUCK	30	5.425	5.135			[TRUCK	$1.20	TON	SAVING	6.2¢]				
7 HARRISON COUNTY, OHIO TO DETROIT	10.44	2.30	4.02	1.09	PC	265	6.375	5.985	4.84					29.0¢			8.0¢	12.7¢	15.9¢
8 MAHONING COUNTY, OHIO TO YOUNGSTOWN	7.64	2.67	3.19	1.04	TRUCK		4.655	4.265			[TRUCK	$1.20	TON	SAVING	5.1¢]				
9 ARMSTRONG COUNTY,PA. TO INDIANA, PA.	12.99	2.53	6.10	1.02	TRUCK	30	6.895	6.465			[TRUCK	$1.20	TON	SAVING	7.8¢]				

TABLE 7-1 continued

SOURCE/DESTINATION PAIRS WITH RELATED INFORMATION

	RAW COAL		CLEAN COAL						SHIPPING COST $/TON RAIL SERVICE				SAVING PER TON				SAVING WITH UNIT TRAIN SERVICE PER TON		
	% ASH	% T.S.	% ASH	% T.S.	CARRIER	APPROX MI.	% BTU INCR.	% TRANS-PORT SAVG	SINGLE CAR	A	B	C	SINGLE CAR	SAVG A	SAVG B	SAVG C	@0.5¢ PER TON-MI	@0.8¢ PER TON-MI	@1.0¢ PER TON-MI
10 ARMSTRONG COUNTY, PA. TO MINE MOUTH	21.55	2.22	7.86	0.99	(NONE)	0	13.69%	12.06%		[NO TRANSPORT COSTS]									
11 BUTLER COUNTY, PA. TO ASTABULA	19.5	1.32	6.7	0.98	B & O	95	10.7%	9.67%	3.35				32.4¢				4.9¢	7.8¢	9.7¢
12 ALLEGHENY COUNTY, PA. TO PITTSBURGH	22.70	1.97	8.55	1.00	TRUCK	20	14.15%	12.4%			[TRUCK $1.00 TON			SAVING	12.4¢]				
13 LAWRENCE COUNTY, PA. TO PITTSBURGH	4.7	2.35	2.5	1.03	B & O	55	2.2%	2.15%	2.16				4.6¢				0.64¢	1.0¢	1.2¢
14 CAMBRIA COUNTY, PA. TO BOSTON	15.95	2.57	4.92	1.03	PF	520	11.03%	9.98%	6.64				66.3¢				26.0¢	42.0¢	52.0¢
15 SOMMERSET COUNTY, PA. TO WASH., D.C.	15.95	2.58	7.10	0.72	B & O	185	8.85%	8.13%	5.17	3.79	4.06	4.48	42.0¢	30.8¢	33.0¢	36.4¢	7.6¢	12.0¢	15.0¢
16 CLEARFIELD COUNTY, PA. TO NEWARK	11.60	2.57	5.66	1.01	PF	500	6.96%	6.48%	5.56				36.1¢				13.0¢	21.0¢	26.0¢
17 JEFFERSON COUNTY, PA. TO DETROIT	8.4	1.31	6.8	1.08	B & O	380	1.6%	1.58%	5.67				8.9¢				3.0¢	5.0¢	6.1¢
18a PRESTON COUNTY, W.VA TO WASH., D.C.	35.76	1.36	11.65	1.31	B & O	230	23.61%	19.1%	5.17	3.79	4.06	4.48	98.5¢	72.4¢	77.5¢	85.7¢	21.6¢	34.0¢	43.0¢
18b PRESTON COUNTY, W.VA TO NEWARK				--	B & O	500			5.56				$106.0				40.7¢	65.0¢	81.0¢
19a PRESTON COUNTY, W.VA TO BALTIMORE	14.36	1.54	5.43	0.73	B & O	240	8.15%	7.53%	5.17	3.79	4.06	4.48	38.9¢	28.5¢	30.6¢	33.8¢	9.1¢	15.0¢	18.3¢

TABLE 7-1 Concluded

SOURCE/DESTINATION PAIRS WITH RELATED INFORMATION

	RAW COAL		CLEAN COAL						SHIPPING COST $/TON RAIL SERVICE				SAVING PER TON				SAVING WITH UNIT TRAIN SERVICE PER TON		
	% ASH	% T.S.	% ASH	% T.S.	CARRIER	APPROX MI.	% BTU INCR.	% TRANS-PORT SAVG	SINGLE CAR	A	B	C	SINGLE CAR	SAVG A	SAVG B	SAVG C	@0.5c PER TON-MI.	@0.8c PER TON-MI.	@1.0c PER TON-MI.
19b PRESTON COUNTY, W.VA TO ROCHESTER					B & O	500			5.48	4.10	4.37	4.79	41.3c	30.9c	32.8c	36.1c	18.9c	30.0c	37.7c
20 PRESTON COUNTY, W.VA. TO WASH.,D.C.	18.50	2.24	8.85	0.99	B & O	230	9.65%	8.8%	5.17	3.79	4.06	4.48	45.5c	33.3c	35.7c	39.5c	10.0c	16.0c	19.8c
21 GRANT COUNTY, W.VA. TO WASH., D.C.	28.48	3.03	11.45	0.95	B & O	215	17.03%	14.6%	5.17	3.79	4.06	4.48	75.3c	55.3c	59.3c	65.5c	15.8c	25.0c	31.4c
22 COLUMBIANA COUNTY, OHIO TO CHICAGO	7.00	1.50	4.0	0.92	PC	430	3.0%	2.9%	5.54				16.1c				6.4c	10.0c	12.8c
23 CLEARFIELD COUNTY, PA. TO CHICAGO	12.4	2.24	7.4	1.20	PC	555	5.0%	4.75%	6.13	(7200) (TONS@) ($5.00)	(5,000) (TONS@) ($5.22)		29.2c	23.8c	24.8c		13.2c	21.0c	26.4c
24 BELL COUNTY, KY. TO CINCINNATI	6.5	1.41	3.0	1.02	L & N	235	3.5%	3.38%	3.90				13.2c				4.0c	6.4c	8.0c
25 LOGAN COUNTY, W.VA. TO COLUMBUS, OHIO	7.5	1.86	5.5	1.15	N & W	235	2.0%	1.96%	4.44				8.7c				2.3c	3.7c	4.6c
26 VIGO COUNTY, IND. TO INDIANAPOLIS	8.5	1.47	4.4	0.95	PC	80	4.1%	3.94%	2.15				8.5c				1.58c	2.5c	3.15c
27 CALDWELL COUNTY, KY. TO INDIANAPOLIS	10.0	1.42	5.5	1.05	IC	275	4.5%	4.3%	3.42				14.7c				5.9c	9.6c	11.9c
28 CALDWELL COUNTY, KY. TO CHICAGO	10.0	1.42	5.5	1.05	IC	395	4.5%	4.3%	4.89	(2,500) (TONS@) ($3.84)		(1,000) (TONS@) ($4.34)	21.0c	16.5c		18.7c	8.5c	13.6c	17.0c
29 FRANKLIN COUNTY, ILL. TO ST. LOUIS	17.0	1.25	10.0	0.95	IC	95	7.0%	6.55%	3.07	(1,250) (TONS@) ($2.59)			20.1c	17.0c			3.11c	5.0c	6.22c
30 FRANKLIN COUNTY, ILL. TO CHICAGO	17.0	1.25	10.0	0.95	IC	280	7.0%	6.55%	4.10	(2,500) (TONS@) ($3.08)		(1,000) (TONS@) ($3.60)	26.8c	20.2c		23.6c	9.8c	16.0c	19.6c

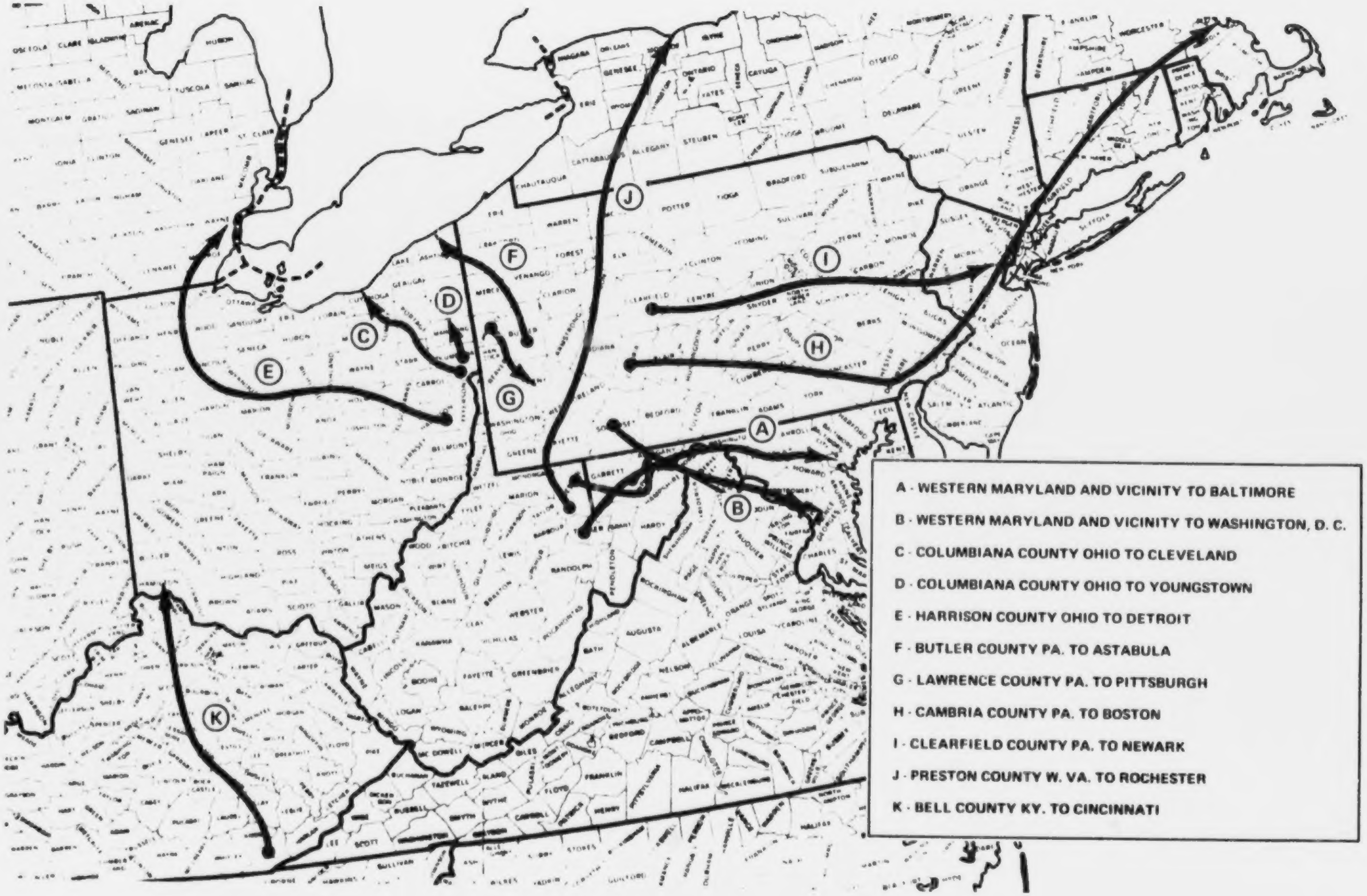

A - WESTERN MARYLAND AND VICINITY TO BALTIMORE
B - WESTERN MARYLAND AND VICINITY TO WASHINGTON, D. C.
C - COLUMBIANA COUNTY OHIO TO CLEVELAND
D - COLUMBIANA COUNTY OHIO TO YOUNGSTOWN
E - HARRISON COUNTY OHIO TO DETROIT
F - BUTLER COUNTY PA. TO ASTABULA
G - LAWRENCE COUNTY PA. TO PITTSBURGH
H - CAMBRIA COUNTY PA. TO BOSTON
I - CLEARFIELD COUNTY PA. TO NEWARK
J - PRESTON COUNTY W. VA. TO ROCHESTER
K - BELL COUNTY KY. TO CINCINNATI

FIGURE 7-1
SOURCE/DESTINATION POINTS

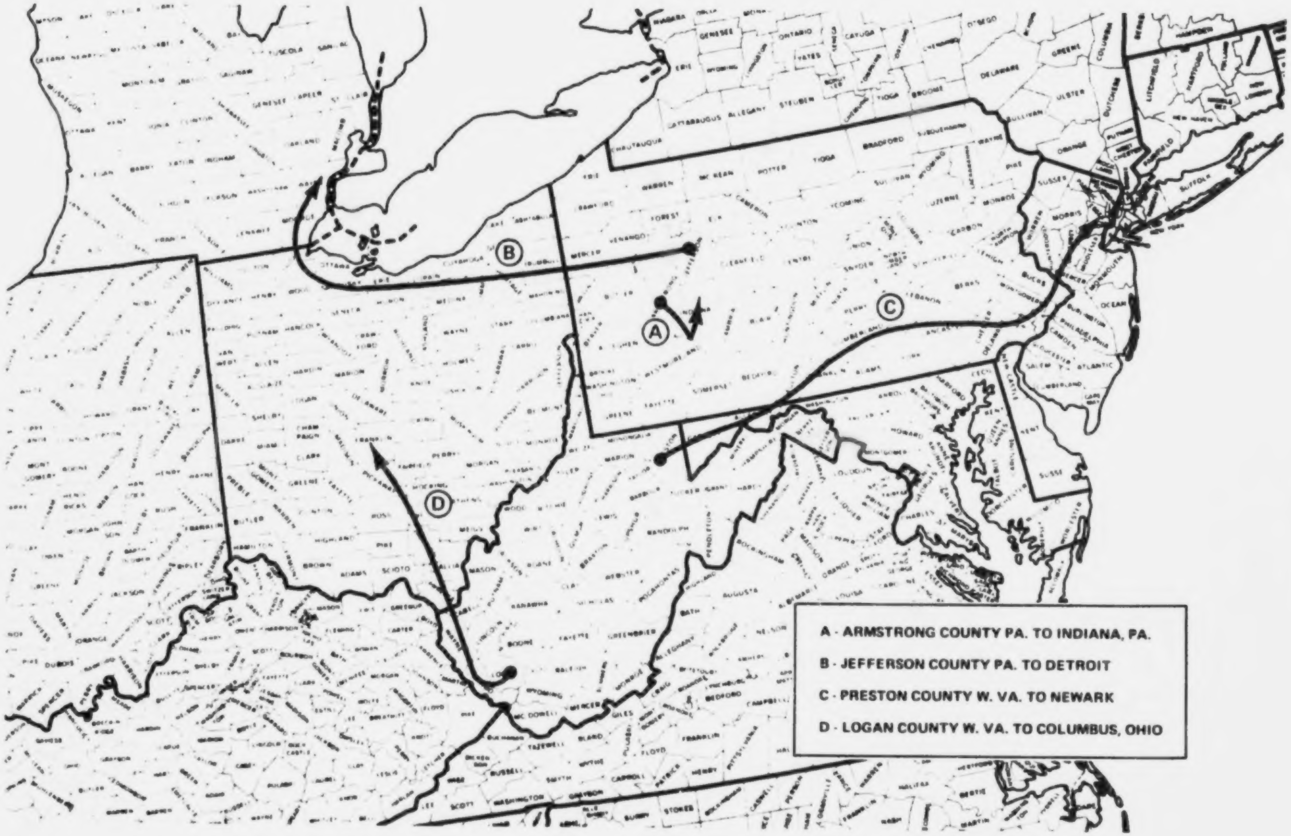
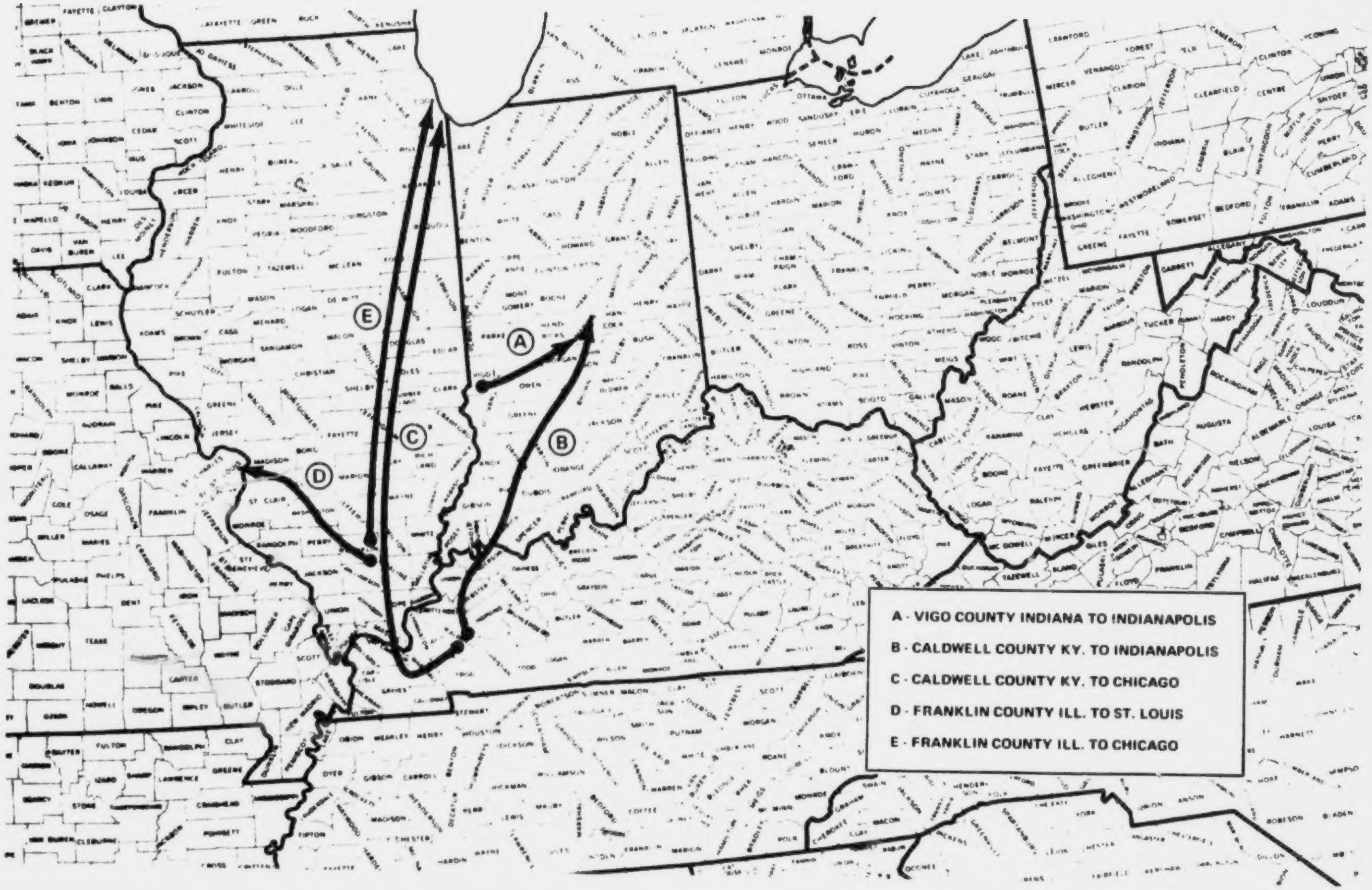

A - ARMSTRONG COUNTY PA. TO INDIANA, PA.
B - JEFFERSON COUNTY PA. TO DETROIT
C - PRESTON COUNTY W. VA. TO NEWARK
D - LOGAN COUNTY W. VA. TO COLUMBUS, OHIO
Ⓐ
Ⓑ
Ⓒ
Ⓓ

FIGURE 7-2
SOURCE/DESTINATION POINTS


Ⓐ
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A - VIGO COUNTY INDIANA TO INDIANAPOLIS
B - CALDWELL COUNTY KY. TO INDIANAPOLIS
C - CALDWELL COUNTY KY. TO CHICAGO
D - FRANKLIN COUNTY ILL. TO ST. LOUIS
E - FRANKLIN COUNTY ILL. TO CHICAGO

FIGURE 7-3
SOURCE/DESTINATION POINTS

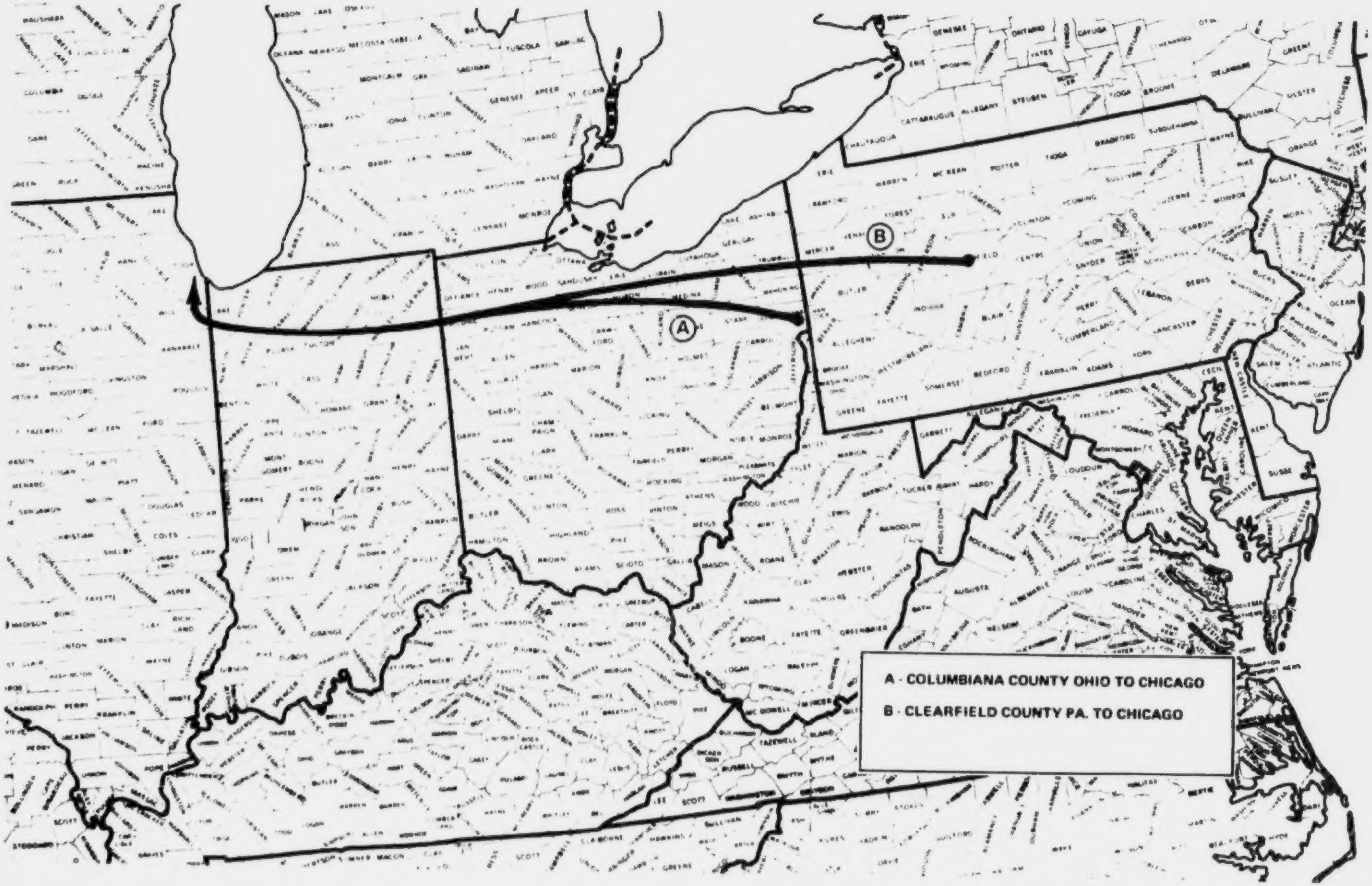
A - COLUMBIANA COUNTY OHIO TO CHICAGO
B - CLEARFIELD COUNTY PA. TO CHICAGO
A
B

FIGURE 7-4
SOURCE/DESTINATION POINTS

each selected pair as described in Table 7-1. All costs in Table 7-1 are in terms of dollars per ton unless specifically stated otherwise. Rail service rates A, B, C, and Single Car (discussed in Section 6.0) listed in Table 7-1 are defined as follows:

- Rate A - 7000 ton train, all coal originating from not more than two origins using same assembly point
- Rate B - 7000 ton train, coal originating from three or more origins using same assembly point
- Rate C - Smaller trains, 4500 tons from one or more origins using same assembly point
- Single Car (Self explanatory)

7.2 Case Example

For Case 1a, the first listed source/destination pair, the economic findings are given in detail on the supporting tabulation sheets. On these sheets, both costs and benefits are itemized, thereby indicating the economic sensitivity to the individual items that comprise a cost/benefit analysis. A summary sheet showing the net cost to benefit differential (in dollars per ton) is also provided. For the remaining 29 source/destination pairs, only these differential cost summary sheets are contained in this section. A detailed economic analysis for each selected source/destination pair similar to that indicated for case 1a, is provided in Appendix VI. Appendix VII develops a cost/benefit analysis model and associated computer program for rapid economic analysis of any potential clean coal source/user combination.

Case Example

CASE # 1a

A. CASE CONDITIONS

1. Mine Location ALLEGANY COUNTY, MARYLAND
2. Consumer Location BALTIMORE, MARYLAND
3. Raw Coal: 20.3 % Ash 1.13 % Total Sulfur
4. Cleaned Coal: 13.1 % Ash 1.06 % Total Sulfur
5. Heat Content of Cleaned Coal: 11,200 BTUs/pound
6. Cleaning Plant Yield = 81 %
7. Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)
8. Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

B. COST FACTORS

1. Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton
2. Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton
3. "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -
   - $4.00/ton, additional cost is . . . . . .$ 0.93 /ton
   - $5.00/ton, additional cost is . . . . . .$ 1.18 /ton
   - $6.00/ton, additional cost is . . . . . .$ 1.41 /ton
4. Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 1a Continued

C. TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.95 /ton

$5.00/ton, differential cost is . . . .$ 2.20 /ton

$6.00/ton, differential cost is . . . .$ 2.43 /ton

D. ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

1. Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

   $5.00/ton, benefit is . . . .$ 0.34 /ton

   $6.00/ton, benefit is . . . .$ 0.40 /ton

   $7.00/ton, benefit is . . . .$ 0.47 /ton

2. Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

   Saving on single car shipment . . . . . .$ 0.35 /ton

   Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.09 /ton

3. Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4. Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

5. Saving in benefit payment (Figure 6-8). . . .$ 0.03 /ton

6. Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 1a Continued

E. TOTAL BENEFITS ASSESSMENT

1. Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.03 /ton

$6.00/ton, benefit is . . . .$ 1.09 /ton

$7.00/ton, benefit is . . . .$ 1.16 /ton

2. Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.77 /ton

$6.00/ton, benefit is . . . .$ 0.83 /ton

$7.00/ton, benefit is . . . .$ 0.90 /ton

F. SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

1. For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.92	0.86	0.79
$5.00	---	1.11	1.04
$6.00	---	---	1.27

2. For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.18	1.12	1.05
$5.00	---	1.37	1.30
$6.00	---	---	1.53

7.3 The Effect of Cleaning Plant Utilization on the Economics of Physically Cleaned Coal

Cleaning plant utilization only affects two cost factors associated with the economics of "deep"-cleaned coal. These are the amortization cost and the tax burden attributable to or associated with each ton of processed coal.

The change in cleaning cost and resulting change in cleaning costs over benefits (per ton) due to a change in cleaning plant utilization is simply the sum of the changes in amortization and tax values. For a plant costing $8000 per ton hour input capacity, the amortization and tax burdens are obtainable from Figures 5-3 and 5-6. For such a plant operated at 38.5% utilization (study assumed value) and providing a 90% yield, the amortization burden is 38.5¢ and the tax burden is 5.4¢ per ton of cleaned coal. If the utilization of the cleaning plant is 50%, the amortization burden will be 30¢ and the tax burden 4.1¢ per ton of cleaned coal. Therefore, the reduction in cleaning cost (or cost over benefit value) will be (38.5 - 30) + (5.4 - 4.1) cents (i.e., ≈ 10¢) per ton of cleaned coal.

If, when operating at a 90% yield, cleaning plant utilization changes from 38.5% to 20%, then the increase in cleaning cost would be (74 - 38.5) + (10 - 5.4) cents (i.e., ≈ 40¢) per ton of cleaned coal. This increase in cost when going to lower cleaning plant utilization is evident from the shapes of both the amortization and tax benefit curves (Figures 5-3 and 5-6).

7.4 Differential Cost Summaries

As previously indicated, a detailed economic analysis for each of the 30 source/destination pairs is provided in Appendix VI. For each pair, the analysis conditions and the economic summary are provided in this section.

Overall distribution summaries for selected raw coal values and F.O.B. raw coal costs are provided by Figures 7-5 through 7-8. These overall distribution summaries reflect the economic evaluations resulting from case studies on both a per ton of physically cleaned coal basis and on a per MBTU basis. The per MBTU value is based on the approximate moist, mineral matter-free analysis of each case study coal source.[7,14] The BTU value of each coal source after cleaning was calculated from this moist, mineral matter-free value to reflect the mineral content of the cleaned coal. In this calculation, moist refers to coal containing only its natural inherent moisture.

Figures 7-5 and 7-6 provide the economic distribution summaries on a per ton of cleaned coal basis. These figures indicate that in over 65% of the cases examined, the differential cost increase through the use of cleaned coal amounts to less than one dollar a ton.

Figures 7-7 and 7-8 provide the economic distribution based on a per MBTU basis. These figures indicate that in over 75% of the cases examined, the differential cost increase through the use of cleaned coal translates to less than 5¢ per MBTU.

An examination of general coal source/destination case economics shows that for a given per ton raw coal value, the economics of using cleaned coal becomes more favorable as F.O.B. raw coal cost, transportation charges, and coal volume dependent costs become greater. For the examined 30 source/destination pairs, the major benefit impactors are (1) F.O.B. raw coal cost and (2) transportation charges. In essence, if F.O.B. raw coal and/or transportation cost(s) increase, the associated benefit factors also increase. If the mining cost (raw coal value) remains constant in the face of these increases, then the differential cost of using cleaned coal decreases.

CASE 1A

Mine Location: ALLEGANY COUNTY, MARYLAND

Consumer Location: BALTIMORE, MARYLAND

Raw Coal: 20.3% Ash; 1.13 % Sulfur

Deep-Cleaned Coal: 13.1% Ash; 1.06 % Sulfur

Cleaning Plant Yield: 81 %

Heat Content of Cleaned Coal: 11,200 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.0	$7.00	$5.00	$6.00	$7.00
$4.00	0.92	0.86	0.79	1.18	1.12	1.05
$5.00	---	1.11	1.04	---	1.37	1.30
$6.00	---	---	1.27	---	---	1.53

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 1B

Mine Location: ALLEGANY COUNTY, MARYLAND

Consumer Location: WASHINGTON

Raw Coal: 20.3 % Ash; 1.13 % Sulfur

Deep-Cleaned Coal: 13.1 % Ash; 1.06 % Sulfur

Cleaning Plant Yield: 81 %

Heat Content of Cleaned Coal: 11,200 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.92	0.86	0.79	1.19	1.13	1.06
$5.00	---	1.11	1.04	---	1.38	1.31
$6.00	---	---	1.27	---	---	1.54

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 2

Mine Location: GARRET COUNTY, MARYLAND

Consumer Location: BALTIMORE, MARYLAND

Raw Coal: 12.0% Ash; 0.96 % Sulfur

Deep-Cleaned Coal: 8.0% Ash; 0.64 % Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 12,000 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.73	0.69	0.65	0.86	0.82	0.78
$5.00	---	0.79	0.75	---	0.92	0.88
$6.00	---	---	0.87	---	---	1.00

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 3

Mine Location: GARRETT COUNTY, MARYLAND

Consumer Location: WASHINGTON, D. C.

Raw Coal: 14.4 % Ash; 1.14 % Sulfur

Deep-Cleaned Coal: 9.6 % Ash; 0.82 % Sulfur

Cleaning Plant Yield: 89 %

Heat Content of Cleaned Coal: 11,700 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.68	0.63	0.59	0.85	0.80	0.76
$5.00	---	0.75	0.71	---	0.92	0.88
$6.00	---	---	0.83	---	---	1.00

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 4

Mine Location: ALLEGANY COUNTY, MARYLAND

Consumer Location: BALTIMORE, MARYLAND

Raw Coal: 11.9 % Ash; 1.13 % Sulfur

Deep-Cleaned Coal: 10.6 % Ash; 1.07 % Sulfur

Cleaning Plant Yield: 97 %

Heat Content of Cleaned Coal: 11,600 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.72	0.70	0.69	0.77	0.75	0.74
$5.00	---	0.72	0.71	---	0.77	0.76
$6.00	---	---	0.75	---	---	0.80

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 5

Mine Location: COLUMBIANA COUNTY, OHIO

Consumer Location: CLEVELAND, OHIO

Raw Coal: 10.39 % Ash; 2.34 % Sulfur

Deep-Cleaned Coal: 4.68 % Ash; 0.62 % Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 12,400 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.55	0.50	0.44	0.71	0.66	0.60
$5.00	---	0.61	0.55	---	0.77	0.71
$6.00	---	---	0.67	---	---	0.83

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 6

Mine Location: COLUMBIANA COUNTY, OHIO

Consumer Location: YOUNGSTOWN, OHIO

Raw Coal: 9.32% Ash; 2.39% Sulfur

Deep-Cleaned Coal: 3.90% Ash; 0.99% Sulfur

Cleaning Plant Yield: 85 %

Heat Content of Cleaned Coal: 12,400 BTUs/pound

Raw Coal Value (per ton)	TRUCK SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.08	1.03	0.98
$5.00	---	1.21	1.16
$6.00	---	---	1.35

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 7

Mine Location: HARRISON COUNTY, OHIO

Consumer Location: DETROIT, MICHIGAN

Raw Coal: 10.44 % Ash; 2.30 % Sulfur

Deep-Cleaned Coal: 4.07 % Ash; 1.09 % Sulfur

Cleaning Plant Yield: 85 %

Heat Content of Cleaned Coal: 12,400 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.75	0.69	0.63	0.91	0.85	0.81
$5.00	---	0.87	0.81	---	1.03	0.97
$6.00	---	---	1.00	---	---	1.16

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 8

Mine Location: MAHONING COUNTY, OHIO

Consumer Location: YOUNGSTOWN, OHIO

Raw Coal: 7.64% Ash; 2.67% Sulfur

Deep-Cleaned Coal: 3.19% Ash; 1.04% Sulfur

Cleaning Plant Yield: 86 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	TRUCK SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.10	1.05	1.01
$5.00	---	1.22	1.18
$6.00	---	---	1.34

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 9

Mine Location: ARMSTRONG COUNTY, PENNSYLVANIA

Consumer Location: INDIANA, PENNSYLVANIA

Raw Coal: 12.99 % Ash; 2.53 % Sulfur

Deep-Cleaned Coal: 6.10 % Ash; 1.02 % Sulfur

Cleaning Plant Yield: 87 %

Heat Content of Cleaned Coal: 12,200 BTUs/pound

Raw Coal Value (per ton)	TRUCK SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.79	0.72	0.66
$5.00	---	0.87	0.81
$6.00	---	---	0.96

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 10

Mine Location: ARMSTRONG COUNTY, PENNSYLVANIA

Consumer Location: (MINE MOUTH)

Raw Coal: 21.55% Ash; 2.22% Sulfur

Deep-Cleaned Coal: 7.86% Ash; 0.99% Sulfur

Cleaning Plant Yield: 78 %

Heat Content of Cleaned Coal: 11,900 BTUs/pound

Raw Coal Value (per ton)	NO SHIPPING F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.01	0.89	0.77
$5.00	---	1.17	1.05
$6.00	---	---	1.43

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 11

Mine Location: BUTLER COUNTY, PENNSYLVANIA

Consumer Location: ASTABULA, OHIO

Raw Coal: 19.4 % Ash; 1.32 % Sulfur

Deep-Cleaned Coal: 8.7 % Ash; 0.98 % Sulfur

Cleaning Plant Yield: 80 %

Heat Content of Cleaned Coal: 11,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.77	0.67	0.57	1.01	0.91	0.81
$5.00	---	0.92	0.82	---	1.16	1.06
$6.00	---	---	1.07	---	---	1.31

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 12

Mine Location: ALLEGHENY COUNTY, PENNSYLVANIA

Consumer Location: PITTSBURGH, PENNSYLVANIA

Raw Coal: 22.70% Ash; 1.97% Sulfur

Deep-Cleaned Coal: 8.55% Ash; 1.00% Sulfur

Cleaning Plant Yield: 76 %

Heat Content of Cleaned Coal: 12,300 BTUs/pound

Raw Coal Value (per ton)	TRUCK SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.02	0.90	0.77
$5.00	---	1.21	1.08
$6.00	---	---	1.39

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 13

Mine Location: LAWRENCE COUNTY, PENNSYLVANIA

Consumer Location: PITTSBURGH, PENNSYLVANIA

Raw Coal: 4.7 % Ash; 2.35 % Sulfur

Deep-Cleaned Coal: 2.5 % Ash; 1.03 % Sulfur

Cleaning Plant Yield: 95 %

Heat Content of Cleaned Coal: 12,000 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.71	0.69	0.67	0.75	0.73	0.71
$5.00	---	0.74	0.72	---	0.78	0.76
$6.00	---	---	0.77	---	---	0.81

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 14

Mine Location: CAMBRIA COUNTY, PENNSYLVANIA

Consumer Location: BOSTON, MASSACHUSETTS

Raw Coal: 15.95% Ash; 2.57% Sulfur

Deep-Cleaned Coal: 4.92% Ash; 1.03% Sulfur

Cleaning Plant Yield: 82 %

Heat Content of Cleaned Coal: 13,200 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.24	0.14	0.04	0.48	0.38	0.28
$5.00	---	0.36	0.26	---	0.60	0.50
$6.00	---	---	0.48	---	---	0.72

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 15

Mine Location: SUMMERSET COUNTY, PENNSYLVANIA

Consumer Location: WASHINGTON, D. C.

Raw Coal: 15.95 % Ash; 2.58 % Sulfur

Deep-Cleaned Coal: 7.10 % Ash; 0.72 % Sulfur

Cleaning Plant Yield: 87 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.30	0.22	0.14	0.60	0.52	0.44
$5.00	---	0.37	0.29	---	0.67	0.59
$6.00	---	---	0.44	---	---	0.74

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 16

Mine Location: CLEARFIELD COUNTY, PENNSYLVANIA

Consumer Location: NEWARK, NEW JERSEY

Raw Coal: 11.60% Ash; 2.57% Sulfur

Deep-Cleaned Coal: 4.66% Ash; 1.01% Sulfur

Cleaning Plant Yield: 81 %

Heat Content of Cleaned Coal: 12,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.93	0.87	0.80	1.08	1.02	0.95
$5.00	---	1.10	1.03	---	1.25	1.18
$6.00	---	---	1.26	---	---	1.41

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 17

Mine Location: JEFFERSON COUNTY, PENNSYLVANIA

Consumer Location: DETROIT, MICHIGAN

Raw Coal: 8.4 % Ash; 1.33 % Sulfur

Deep-Cleaned Coal: 6.8 % Ash; 1.08 % Sulfur

Cleaning Plant Yield: 96 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.72	0.71	0.69	0.76	0.75	0.73
$5.00	---	0.75	0.73	---	0.79	0.77
$6.00	---	---	0.77	---	---	0.81

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 18A

Mine Location: PRESTON COUNTY, WEST VIRGINIA

Consumer Location: WASHINGTON, D. C.

Raw Coal: 35.26% Ash; 2.36% Sulfur

Deep-Cleaned Coal: 11.65% Ash; 1.31% Sulfur

Cleaning Plant Yield: 61 %

Heat Content of Cleaned Coal: 11,900 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	1.07	0.88	0.69	1.72	1.53	1.34
$5.00	---	1.53	1.34	---	2.18	1.99
$6.00	---	---	1.98	---	---	2.63

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 18B

Mine Location: PRESTON COUNTY, WEST VIRGINIA

Consumer Location: NEWARK, NEW JERSEY

Raw Coal: 35.26 % Ash; 2.36 % Sulfur

Deep-Cleaned Coal: 11.65 % Ash; 1.31 % Sulfur

Cleaning Plant Yield: 61 %

Heat Content of Cleaned Coal: 11,900 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	1.00	0.81	0.62	1.41	1.22	1.03
$5.00	---	1.46	1.27	---	1.87	1.68
$6.00	---	---	1.91	---	---	2.32

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 19A

Mine Location: PRESTON COUNTY, WEST VIRGINIA

Consumer Location: BALTIMORE, MARYLAND

Raw Coal: 14.76% Ash; 1.44% Sulfur

Deep-Cleaned Coal: 6.61% Ash; 0.73% Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.18	0.11	0.03	0.42	0.35	0.27
$5.00	---	0.22	0.14	---	0.46	0.38
$6.00	---	---	0.26	---	---	0.50

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 19B

Mine Location: PRESTON COUNTY, WEST VIRGINIA

Consumer Location: ROCHESTER, NEW YORK

Raw Coal: 14.76 % Ash; 1.44 % Sulfur

Deep-Cleaned Coal: 6.61 % Ash; 0.73 % Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.16	0.09	0.01	0.27	0.20	0.12
$5.00	---	0.20	0.12	---	0.31	0.23
$6.00	---	---	0.24	---	---	0.35

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 20

Mine Location: PRESTON COUNTY, WEST VIRGINIA

Consumer Location: WASHINGTON, D. C.

Raw Coal: 18.50% Ash; 2.24% Sulfur

Deep-Cleaned Coal: 8.85% Ash; 0.99% Sulfur

Cleaning Plant Yield: 83 %

Heat Content of Cleaned Coal: 12,300 BTUs/pound

	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.48	0.39	0.30	0.78	0.69	0.60
$5.00	---	0.60	0.51	---	0.90	0.81
$6.00	---	---	0.71	---	---	1.01

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 21

Mine Location: GRANT COUNTY, WEST VIRGINIA

Consumer Location: WASHINGTON, D. C.

Raw Coal: 28.48% Ash; 3.03 % Sulfur

Deep-Cleaned Coal: 11.45% Ash; 0.95 % Sulfur

Cleaning Plant Yield: 80 %

Heat Content of Cleaned Coal: 11,900 BTUs/pound

	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	-0.15	-0.29	-0.44	0.35	0.21	0.06
$5.00	---	-0.04	-0.19	---	0.46	0.31
$6.00	---	---	0.06	---	---	0.56

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 22

Mine Location: COLUMBIANA COUNTY, OHIO

Consumer Location: CHICAGO, ILLINOIS

Raw Coal: 7.00% Ash; 1.50% Sulfur

Deep-Cleaned Coal: 4.00% Ash; 0.92% Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 12,500 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.84	0.82	0.79	0.90	0.88	0.85
$5.00	---	0.92	0.89	---	0.98	0.95
$6.00	---	---	1.01	---	---	1.07

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 23

Mine Location: CLEARFIELD COUNTY, PENNSYLVANIA

Consumer Location: CHICAGO, ILLINOIS

Raw Coal: 12.4 % Ash; 2.24 % Sulfur

Deep-Cleaned Coal: 7.4 % Ash; 1.20 % Sulfur

Cleaning Plant Yield: 88 %

Heat Content of Cleaned Coal: 12,400 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.67	0.62	0.58	0.75	0.70	0.66
$5.00	---	0.76	0.72	---	0.84	0.80
$6.00	---	---	0.86	---	---	0.94

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 24

Mine Location: BELL COUNTY, KENTUCKY

Consumer Location: CINCINNATI, OHIO

Raw Coal: 6.50% Ash; 1.41% Sulfur

Deep-Cleaned Coal: 3.00% Ash; 1.02% Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 13,000 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.83	0.80	0.76	0.90	0.87	0.83
$5.00	---	0.91	0.87	---	0.98	0.94
$6.00	---	---	0.99	---	---	1.06

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 25

Mine Location: LOGAN COUNTY, WEST VIRGINIA

Consumer Location: COLUMBUS, OHIO

Raw Coal: 7.5 % Ash; 1.86 % Sulfur

Deep-Cleaned Coal: 5.5 % Ash; 1.15 % Sulfur

Cleaning Plant Yield: 92 %

Heat Content of Cleaned Coal: 13,200 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.88	0.86	0.84	0.93	0.91	0.89
$5.00	---	0.94	0.92	---	0.99	0.97
$6.00	---	---	1.02	---	---	1.07

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 26

Mine Location: VIGO COUNTY, INDIANA

Consumer Location: INDIANAPOLIS, INDIANA

Raw Coal: 8.5 % Ash; 1.47% Sulfur

Deep-Cleaned Coal: 4.4 % Ash; 0.95% Sulfur

Cleaning Plant Yield: 85 %

Heat Content of Cleaned Coal: 11,400 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	1.16	1.12	1.08	1.22	1.18	1.14
$5.00	---	1.30	1.26	---	1.36	1.32
$6.00	---	---	1.44	---	---	1.50

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 27

Mine Location: CALDWELL COUNTY, KENTUCKY

Consumer Location: INDIANAPOLIS, INDIANA

Raw Coal: 10.0 % Ash; 1.42 % Sulfur

Deep-Cleaned Coal: 5.5 % Ash; 1.05 % Sulfur

Cleaning Plant Yield: 80 %

Heat Content of Cleaned Coal: 11,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	1.43	1.39	1.35	1.48	1.44	1.40
$5.00	---	1.64	1.60	---	1.69	1.65
$6.00	---	---	1.85	---	---	1.90

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 28

Mine Location: CALDWELL COUNTY, KENTUCKY

Consumer Location: CHICAGO, ILLINOIS

Raw Coal: 10.0% Ash; 1.42% Sulfur

Deep-Cleaned Coal: 5.5% Ash; 1.05% Sulfur

Cleaning Plant Yield: 80 %

Heat Content of Cleaned Coal: 11,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	1.37	1.33	1.29	1.44	1.40	1.36
$5.00	---	1.58	1.54	---	1.65	1.61
$6.00	---	---	1.79	---	---	1.86

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 29

Mine Location: FRANKLIN COUNTY, ILLINOIS

Consumer Location: ST. LOUIS, MISSOURI

Raw Coal: 17.0 % Ash; 1.25 % Sulfur

Deep-Cleaned Coal: 10.0 % Ash; 0.95 % Sulfur

Cleaning Plant Yield: 88 %

Heat Content of Cleaned Coal: 10,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.57	0.51	0.44	0.72	0.66	0.59
$5.00	---	0.66	0.59	---	0.81	0.74
$6.00	---	---	0.73	---	---	0.88

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

CASE 30

Mine Location: FRANKLIN COUNTY, ILLINOIS

Consumer Location: CHICAGO, ILLINOIS

Raw Coal: 17.0% Ash; 1.25% Sulfur

Deep-Cleaned Coal: 10.0% Ash; 0.95% Sulfur

Cleaning Plant Yield: 90 %

Heat Content of Cleaned Coal: 10,800 BTUs/pound

Raw Coal Value (per ton)	SINGLE CAR SHIPMENT F.O.B. Raw Coal Cost (per ton)			UNIT TRAIN SHIPMENT F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00	$5.00	$6.00	$7.00
$4.00	0.38	0.32	0.25	0.49	0.43	0.36
$5.00	---	0.43	0.36	---	0.54	0.47
$6.00	---	---	0.48	---	---	0.59

Differential Costs (Cleaning Costs less Benefits) in dollars/ton

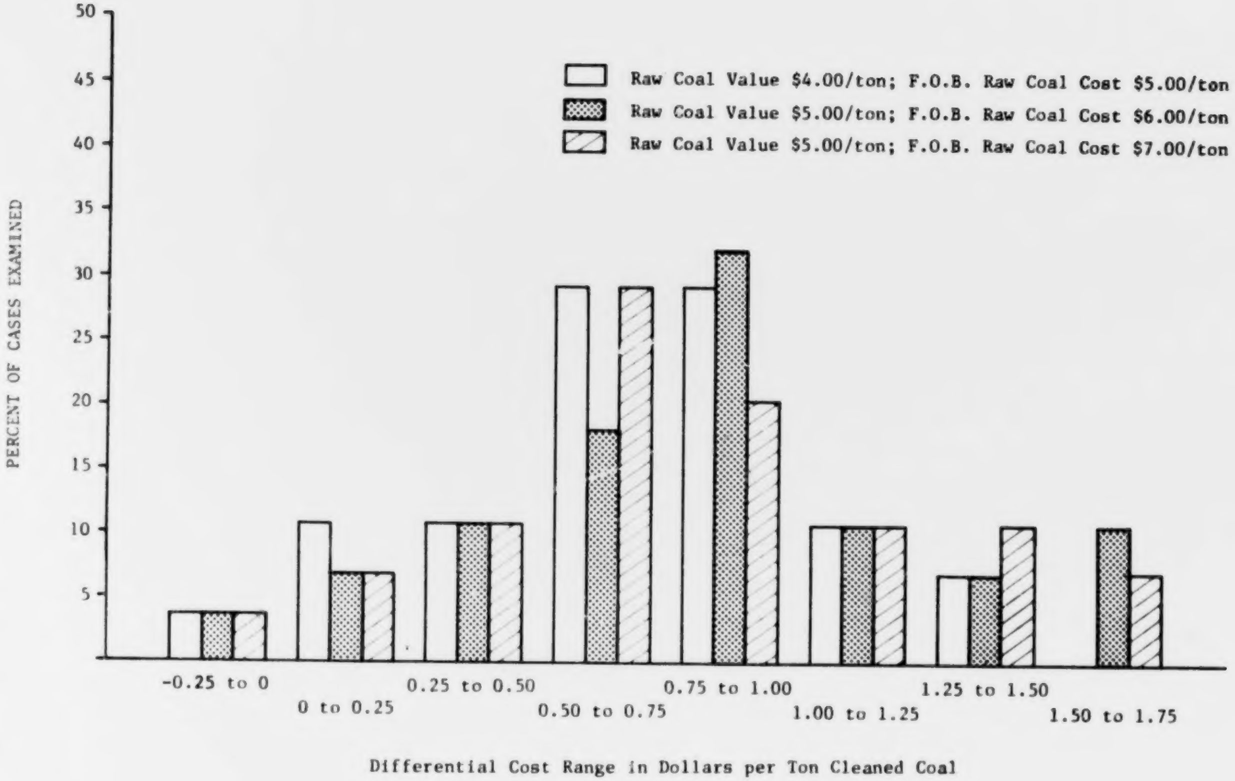

FIGURE 7-5
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - $/TON
(SINGLE CAR SHIPPING RATES)

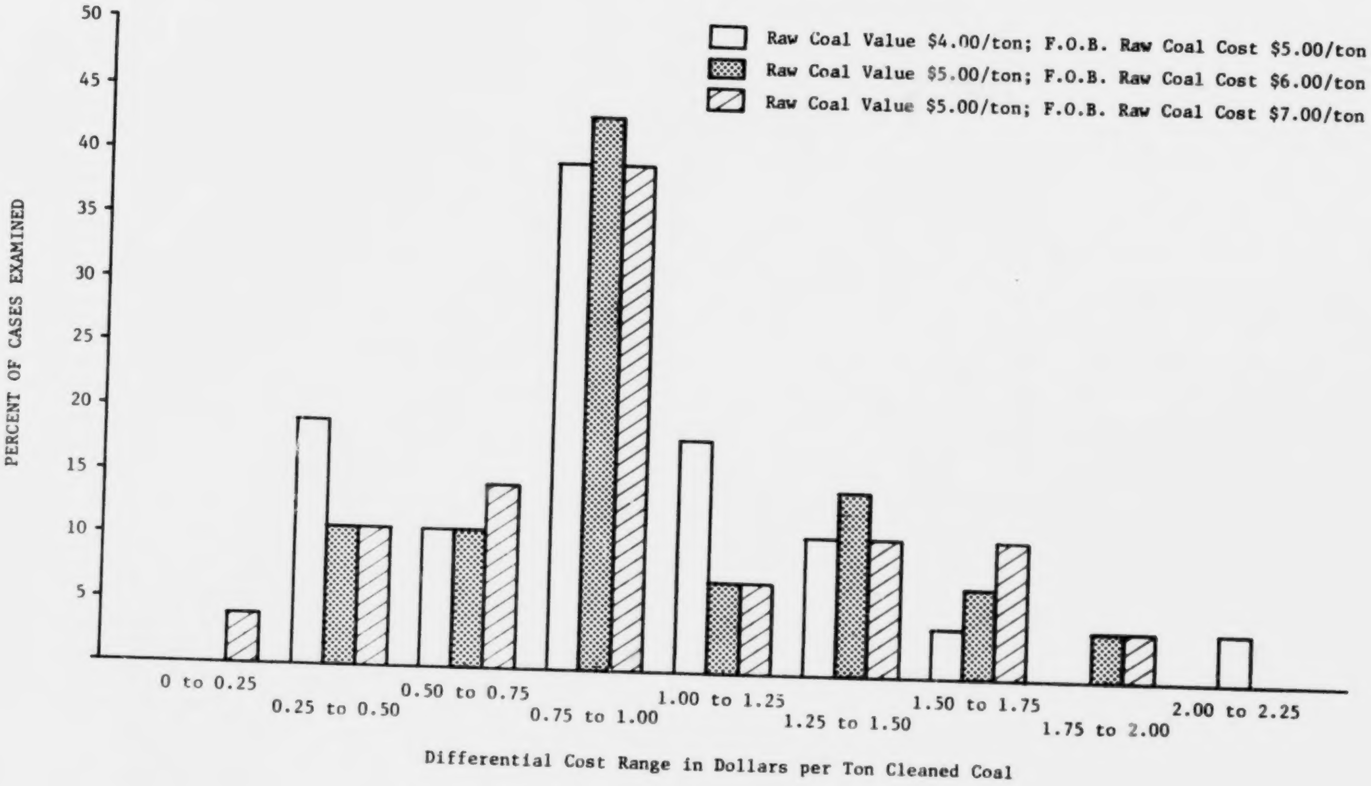

FIGURE 7-6
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - $/TON
(UNIT TRAIN SHIPPING RATES)

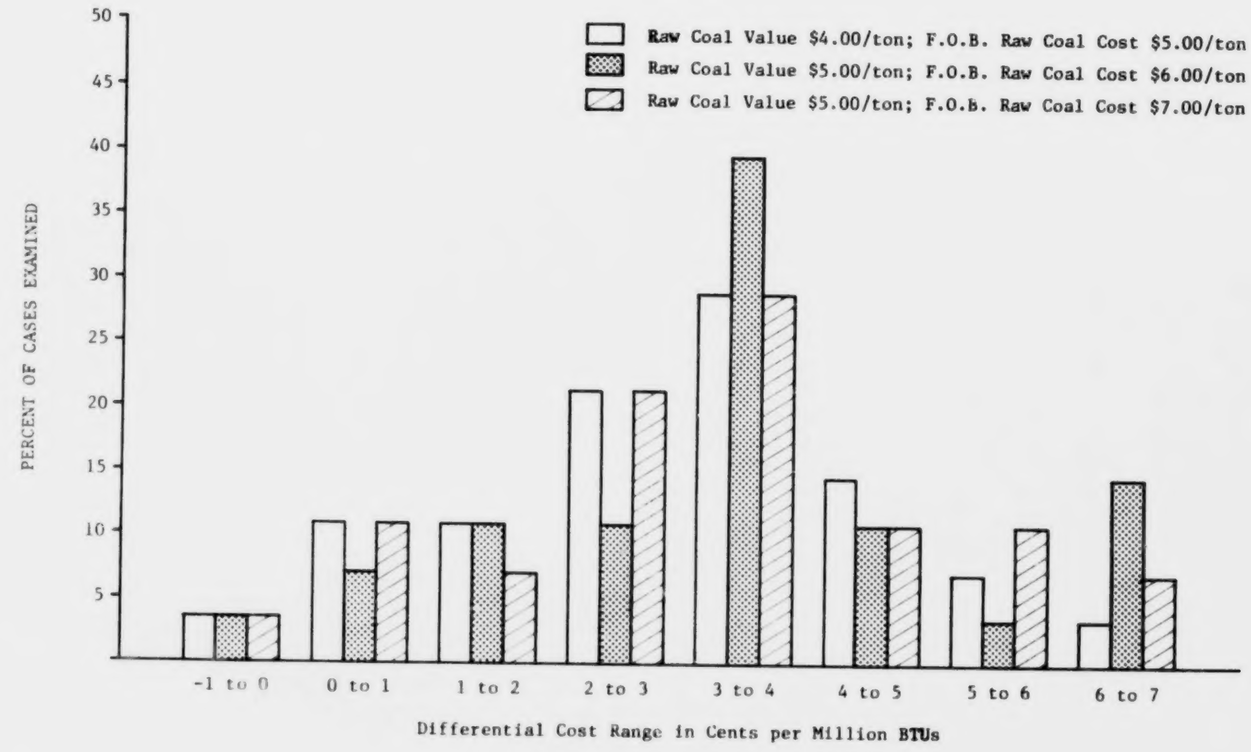

FIGURE 7-7
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - ¢/MBTU
(SINGLE CAR SHIPPING RATES)

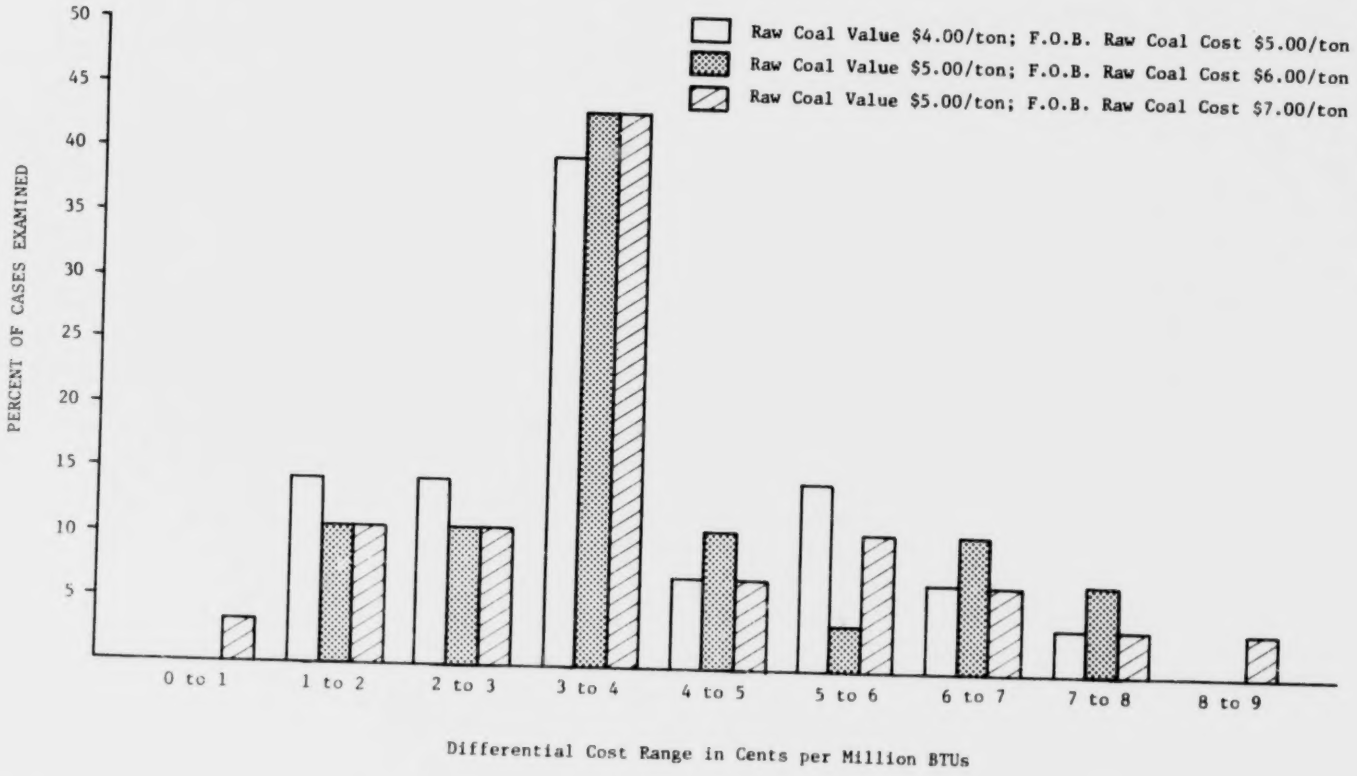

FIGURE 7-8
DIFFERENTIAL CLEANING COSTS LESS BENEFITS - ¢/MBTU
(UNIT TRAIN SHIPPING RATES)

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APPENDIX I
SULFUR CONTENT RELATIONSHIPS

1.0 INTRODUCTION

Sulfur is universally present as an impurity in coal, varying in content from 0.2% to 12.0% by weight as mined. This sulfur may be present in three forms: as pyrite or marcasite, as organic compounds, and as sulfate. The physical cleaning procedures discussed in this paper are designed to remove the pyritic sulfur which may be from 40% to 80% of the total.

The design of the physical cleaning method and the amount of pyrite which can be removed is dependent on the size and dispersal of the pyrite particle. Pyrites in coal occur as highly variable concentrations which may be in the form of lenses, bands, joints, cleats, balls, modules, or as finely disseminated particles. It is this basic variability which creates uncertainty in both estimating the cleanability of a coal source and in designing the physical cleaning process. Sulfur in organic combination is distributed as part of the molecular structure of the coal and generally cannot be removed by physical cleaning procedures. Sulfate sulfur is not a significant percentage of the total sulfur burden and may for all practical purposes be neglected.

2.0 DATA BASE CONSIDERATIONS

The basic limitation of the coal composition and cleanability data references applied in this study is this natural variation in the concentration and particle size of sulfur and ash forming impurities in coal. The analyses described in these references represent approximately 4000 coal samples from 280 counties in 30 coal-producing states and represent most of the coal seams that are mined commercially in the United States. Although the number of analyses seems large, it represents only about one analysis for every 400 million tons of the estimated coal reserve.

In consideration of the natural compositional variability of coal, even this large number of observations can only be used to statistically indicate trends in coal composition through development of probability distributions. No attempt will be made to indicate statistical confidence levels because the quantity and representativeness of analyses varies considerably from one coal source to another. Fortunately, the data base is most comprehensive in the Northern Appalachian Region where it will be shown that the largest exploitable cleanable coal production exists. To improve the accuracy of estimates in this study, two classes of analysis observations were not considered:

- Analyses which were not representative of the coal as mined. Specifically, those samples in Reference 1 which are indicated as tipple samples or are of a size 1 1/2 inch or less. These conditions are indicative that some preparation of the coal may have occurred.

- Analyses from unproductive sources. Some analyses in Reference 1 are 25 to 40 years old and reflect a quality of coal long since consumed. Estimation of samples in this category was made by comparison with Reference 2.

Continuing efforts are being made under the sponsorship of the National Air Pollution Control Administration (NAPCA) to analyze more thoroughly the coal deposits of the Eastern United States. These efforts will improve the confidence in any estimate of the cleanability potential of coal sources.

The results of this clean coal source study are intended as background information in estimating the boundaries of application of physically cleaned coal in meeting SO_2 emission control regulations.

3.0 COAL PRODUCTION AND RESERVES

The origin of coals is normally indicated according to producing districts as established under the Bituminous Coal Act of 1935. These districts are oriented primarily toward coal transportation factors rather than any basic composition of the coal deposits themselves.

For the economic evaluation purposes of this paper, it is convenient to divide the coal deposits indicated in Figure I-1 into four coal-producing regions. These regions, based both on geographical considerations and commonality of total sulfur content, may be identified as follows:

- Western
- Midwestern
- Northern Appalachian
- Southern Appalachian

The total 1968 coal production and estimated remaining coal reserves for each region are indicated in Figures I-2 and I-3, respectively, according to sulfur content.[2,3,4,5,6]

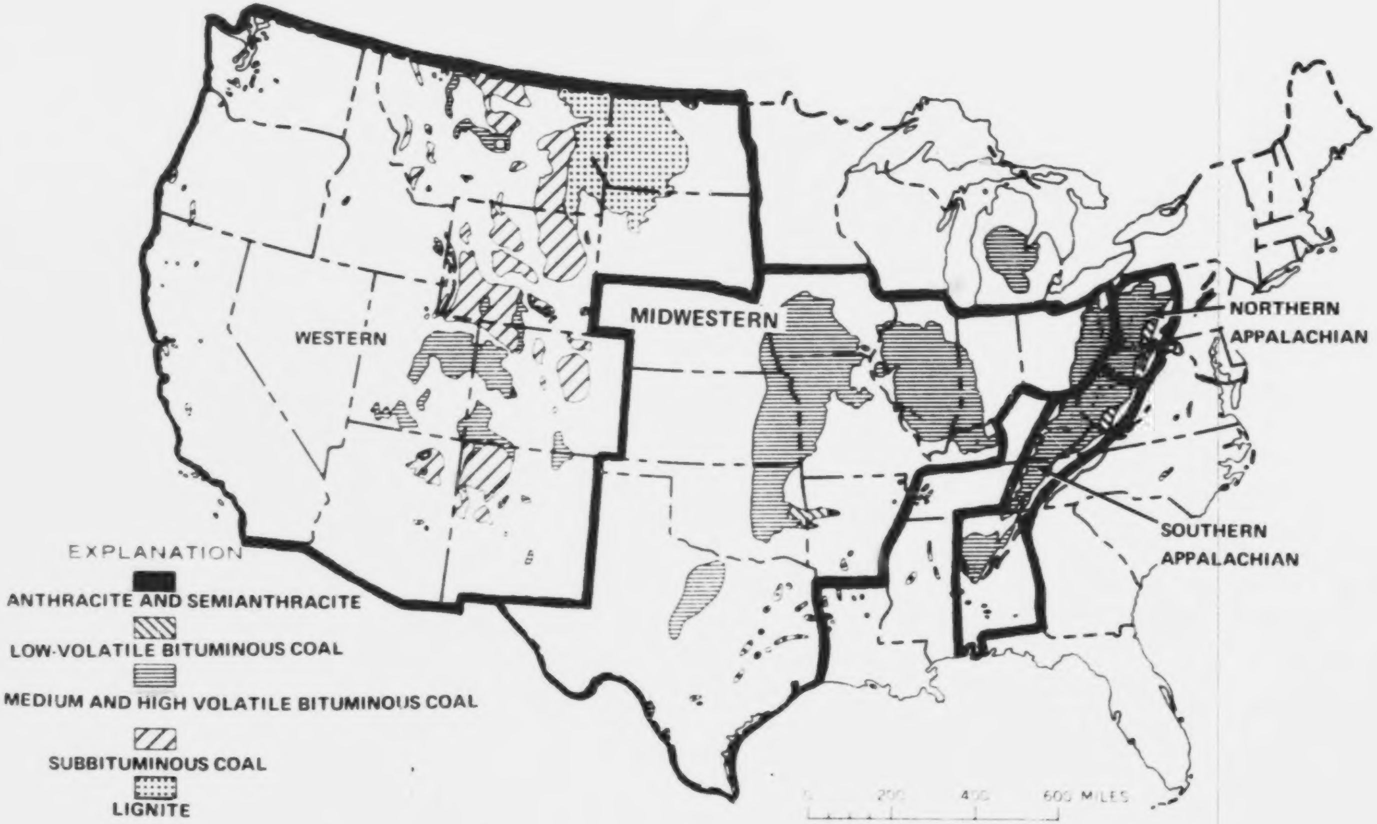

FIGURE I-1

COAL PRODUCING REGIONS

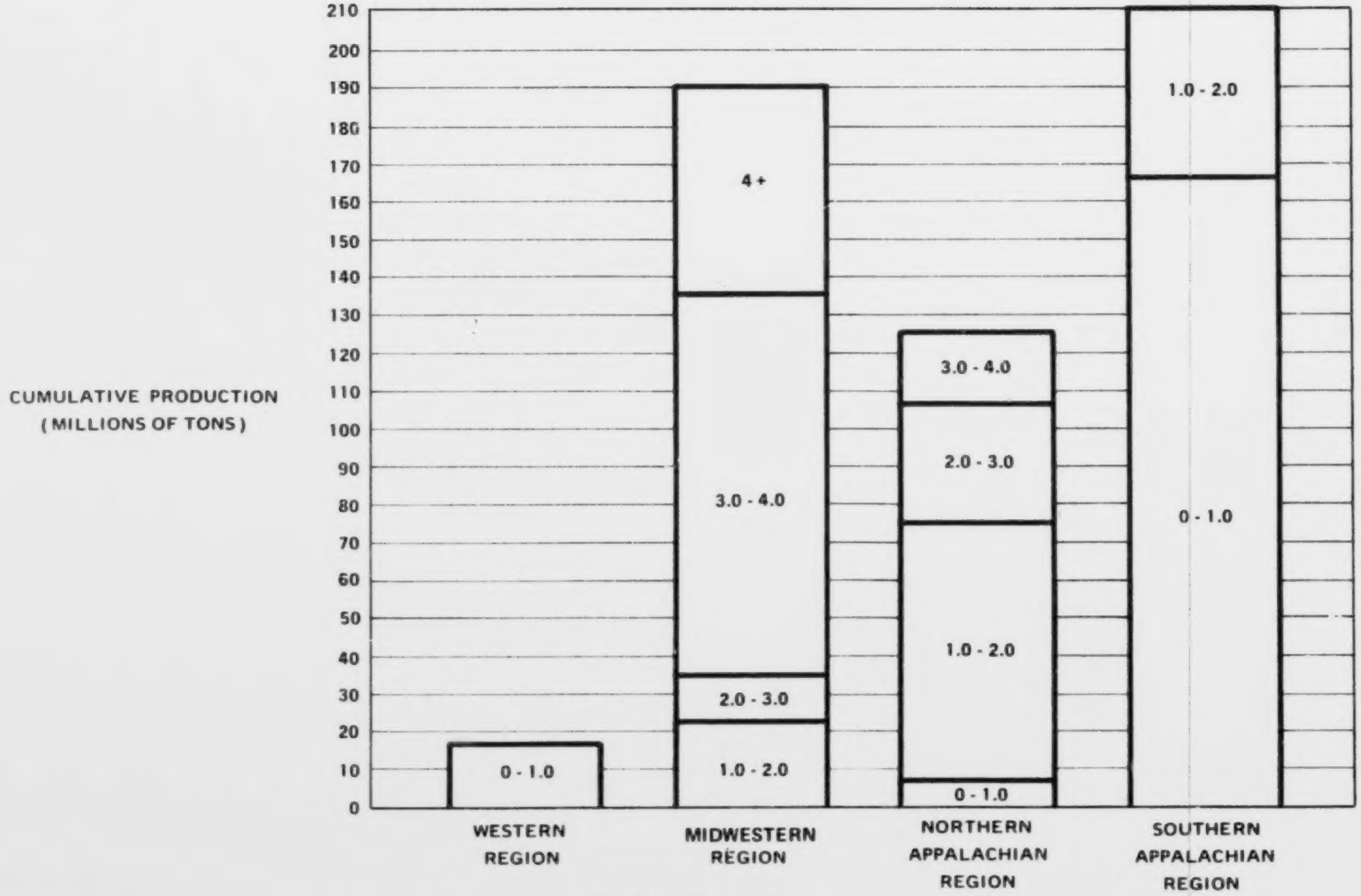

FIGURE I-2

PERCENT SULFUR CONTENT U.S. COAL PRODUCTION BY REGION

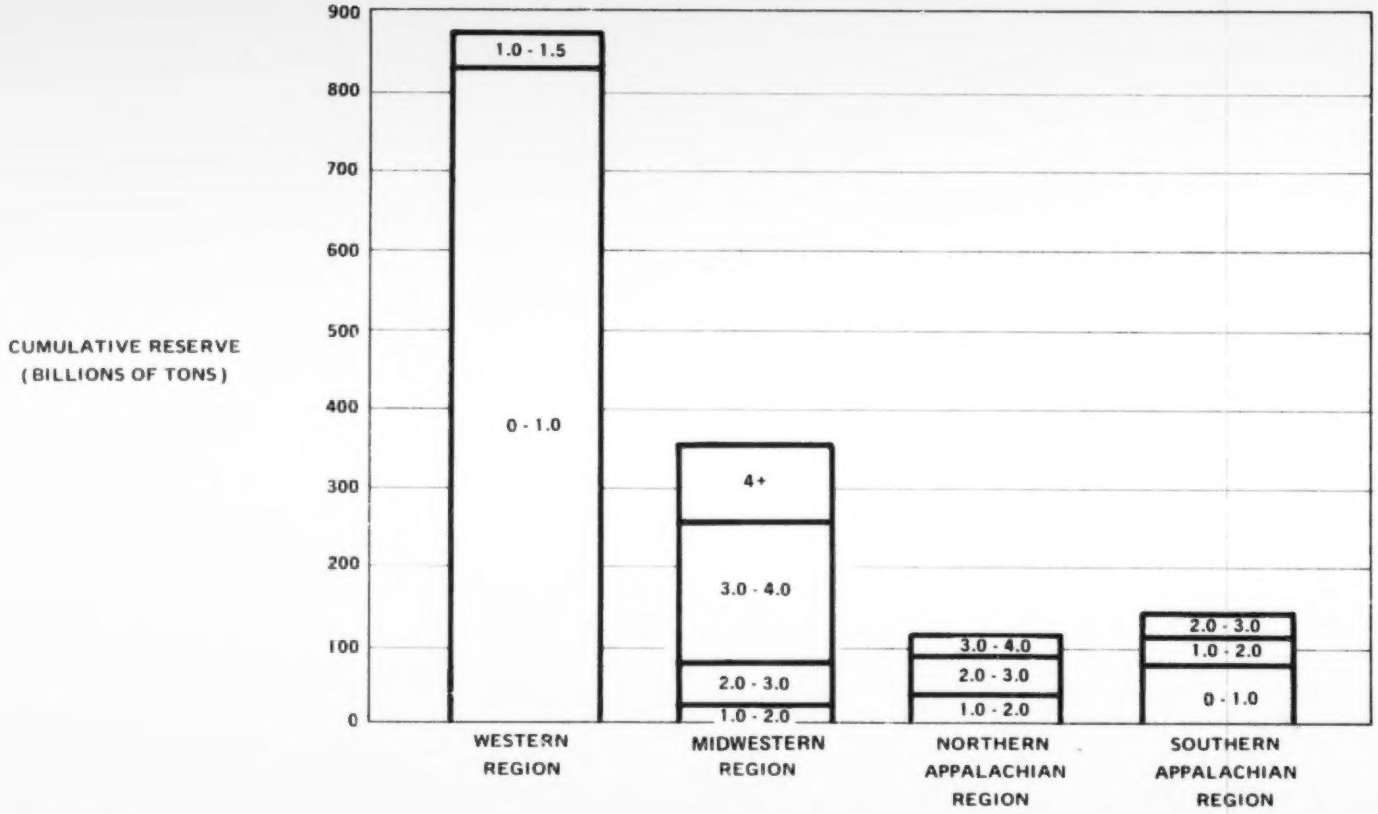

FIGURE I-3

PERCENT SULFUR CONTENT U.S. COAL RESERVE BY REGION

4.0 COAL CLEANING CONDITIONS

4.1 Coal Crushing Size

As coal crushing size is reduced, the percent of pyritic sulfur released from the coal tends to increase. This tendency can vary significantly between coal sources depending on the particular pyrite size and distribution characteristics of the source. The degree of sulfur reduction is generally described in the literature according to four stages of top size crushing.[7,8,9,10]

A. 1 1/2 inch

B. 1/4 to 3/8 inch

C. 14 to 30 mesh

D. Pulverization grind (on the order of 100 to 200 mesh)

For this study, stage B will be examined to estimate the coal production which can be cleaned to a 1% total sulfur level. Stage B is considered the minimum size which can be currently transported economically by rail, barge, or truck without excessive dusting. Thus, this would currently be the minimum practical crushing size for pyrite removal prior to shipment.

4.2 Separation Conditions

The question of separation conditions involves a compromise. For example, in heavy media separation, a tradeoff must be made between achieving maximum separation of the high density pyrite which dictates low specific gravity on the order of 1.30 and the economic desire for maximum coal recovery which requires a relatively high specific gravity fluid. The compromise generally reflected in experimental coal cleaning analysis literature is 1.60. Analyses at this specific gravity indicate a consistent 90% or greater recovery of total coal heat content at the 3/8 inch top size grinding conditions.[7,10] Further study of this variable, relative to the characteristics of each cleanable coal source, should be performed to achieve the optimum tradeoff. It appears from the limited data available that lower specific gravities might be applied advantageously, although the precise conditions must be determined on an individual coal source basis.

5.0 DERIVATION OF SULFUR CONTENT RELATIONSHIPS

Table 4-2 in the body of this report is based on published coal analyses indicating the effect of crushing high-sulfur coals for the liberation of pyritic sulfur.[7,8,10] The translation of these analysis results into first-order estimates of the probability of physically cleaning coal of a given sulfur content to a reduced total sulfur content is indicated by this Appendix. Figures I-4 through I-10 each represent an individual group of coal sources for which a statistically meaningful number of coal cleanability analyses are available.

Figure I-4 through I-7 indicate analyses from individual seams in the Allegheny Seam Group of the Northern Appalachian Region (Pennsylvania, Maryland, Northern West Virginia. Figure I-8 represents the Pittsburgh seam, also of the Northern Appalachian Region.

Figure I-9 represents coal cleanability analyses from Districts 7 and 8 (E. Kentucky, Southern West Virginia, Virginia, Tennessee) of the Southern Appalachian Region. Finally, Figure I-10 describes cleanability analysis results from District 10 (Illinois) of the Midwestern Region.

Each figure plots the total sulfur content of the raw run-of-mine coal sample before the physical cleaning process and its corresponding total sulfur content after cleaning. The cleaning conditions considered in all figures are:

- Crushing to a 3/8 inch top size
- Heavy media separation at a 1.60 specific gravity.

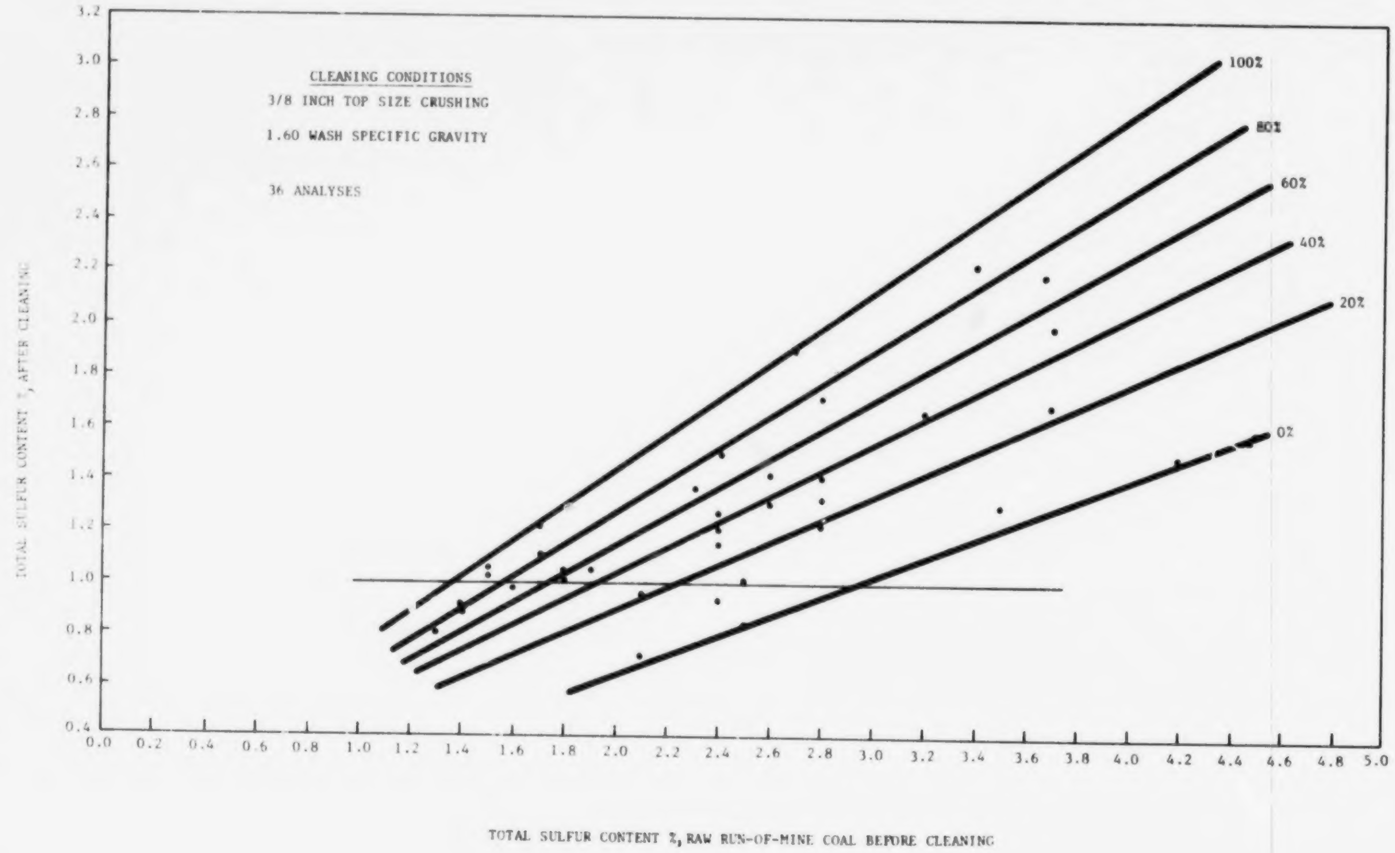

FIGURE I-4
UPPER FREEPORT SEAM

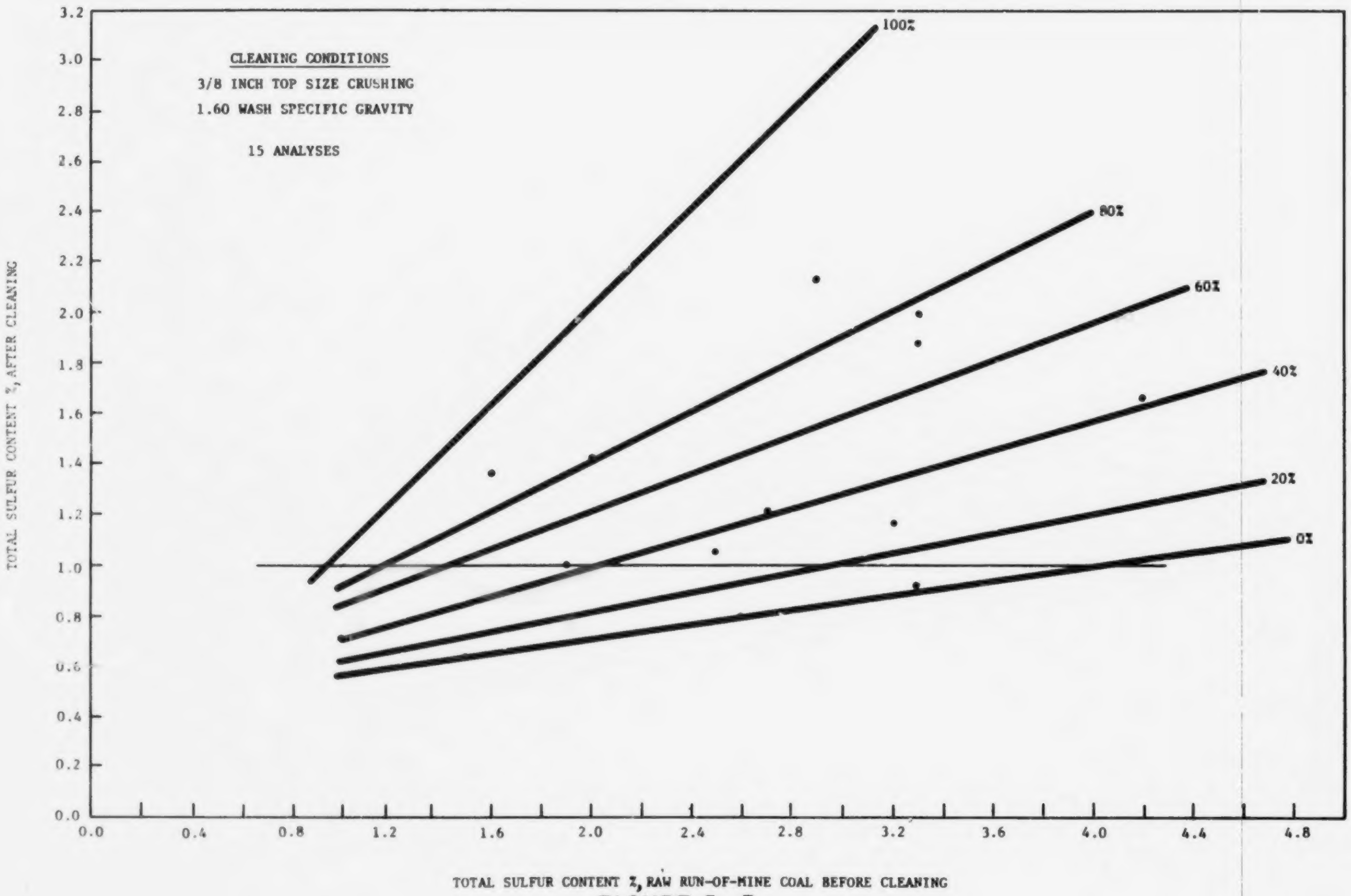

FIGURE I-5
LOWER FREEPORT SEAM

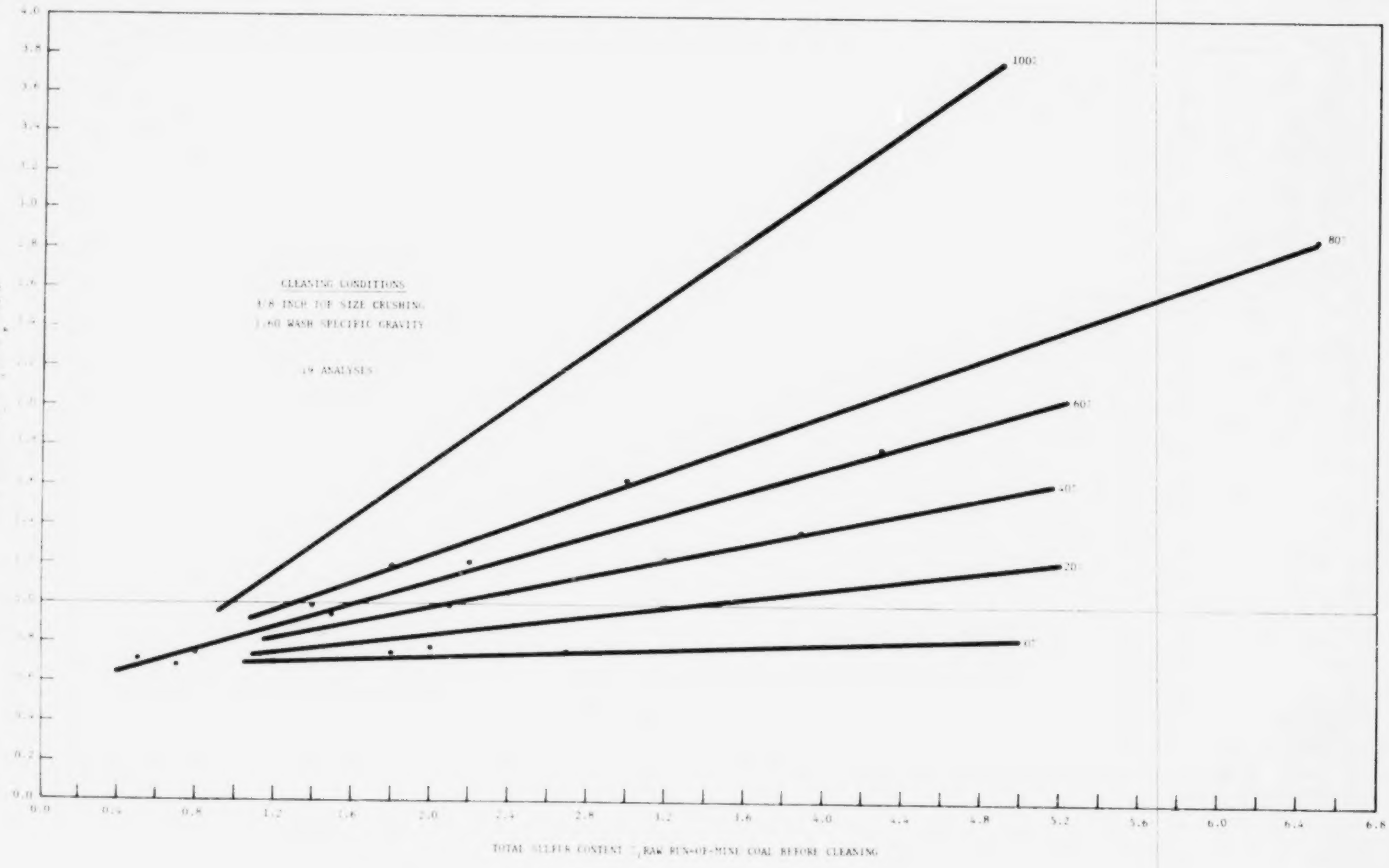

FIGURE I-6
UPPER KITTANNING SEAM

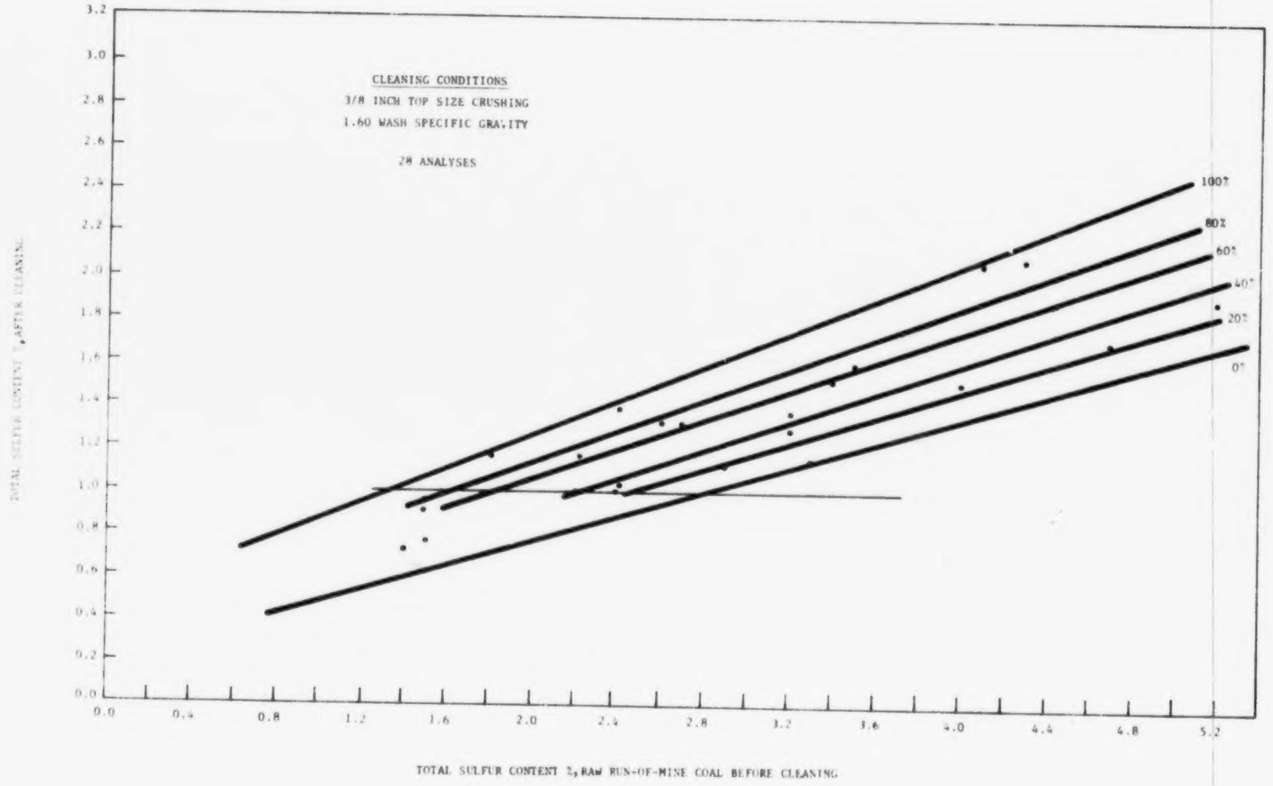

FIGURE I-7
LOWER KITTANNING SEAM

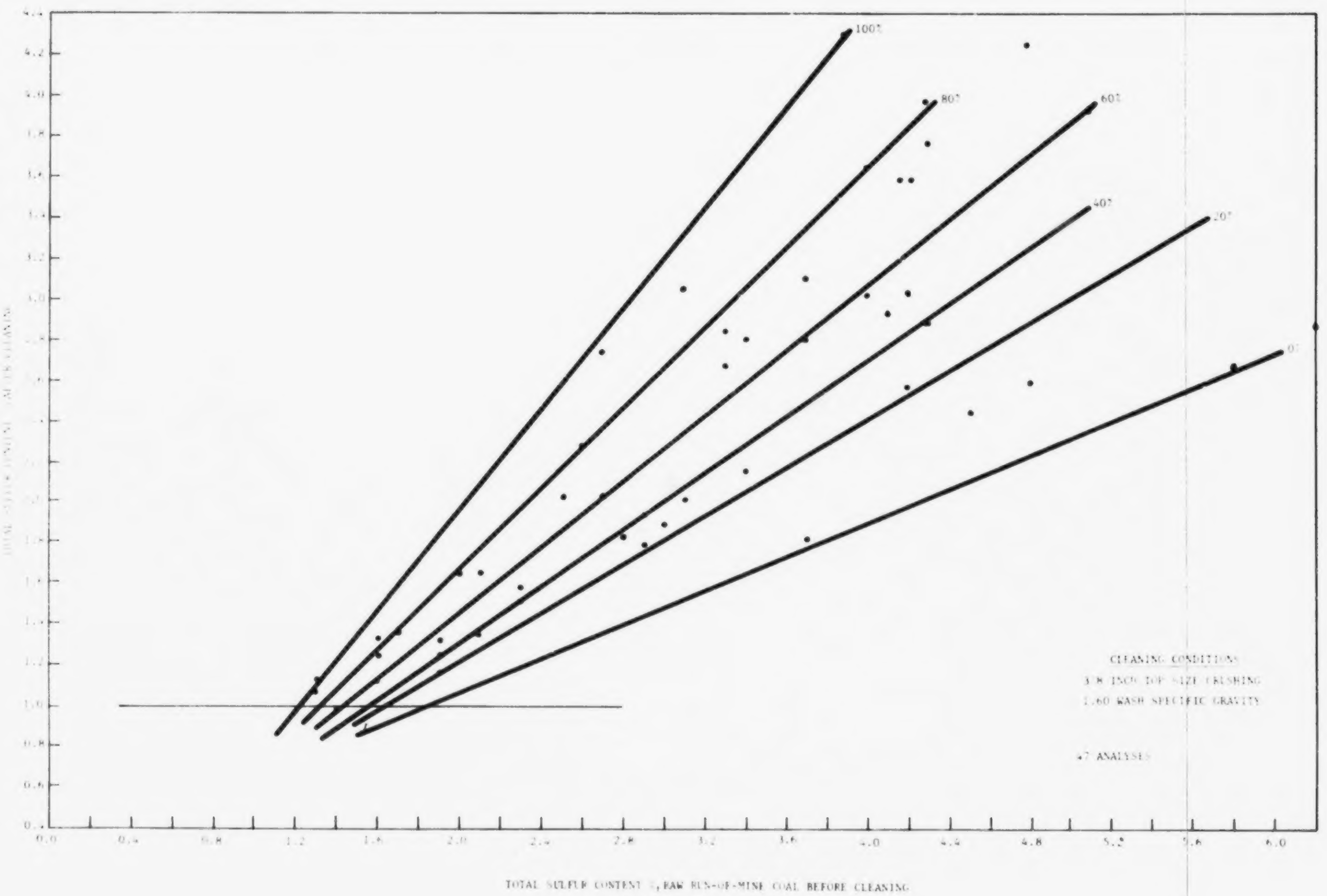

FIGURE I-8
PITTSBURGH SEAM

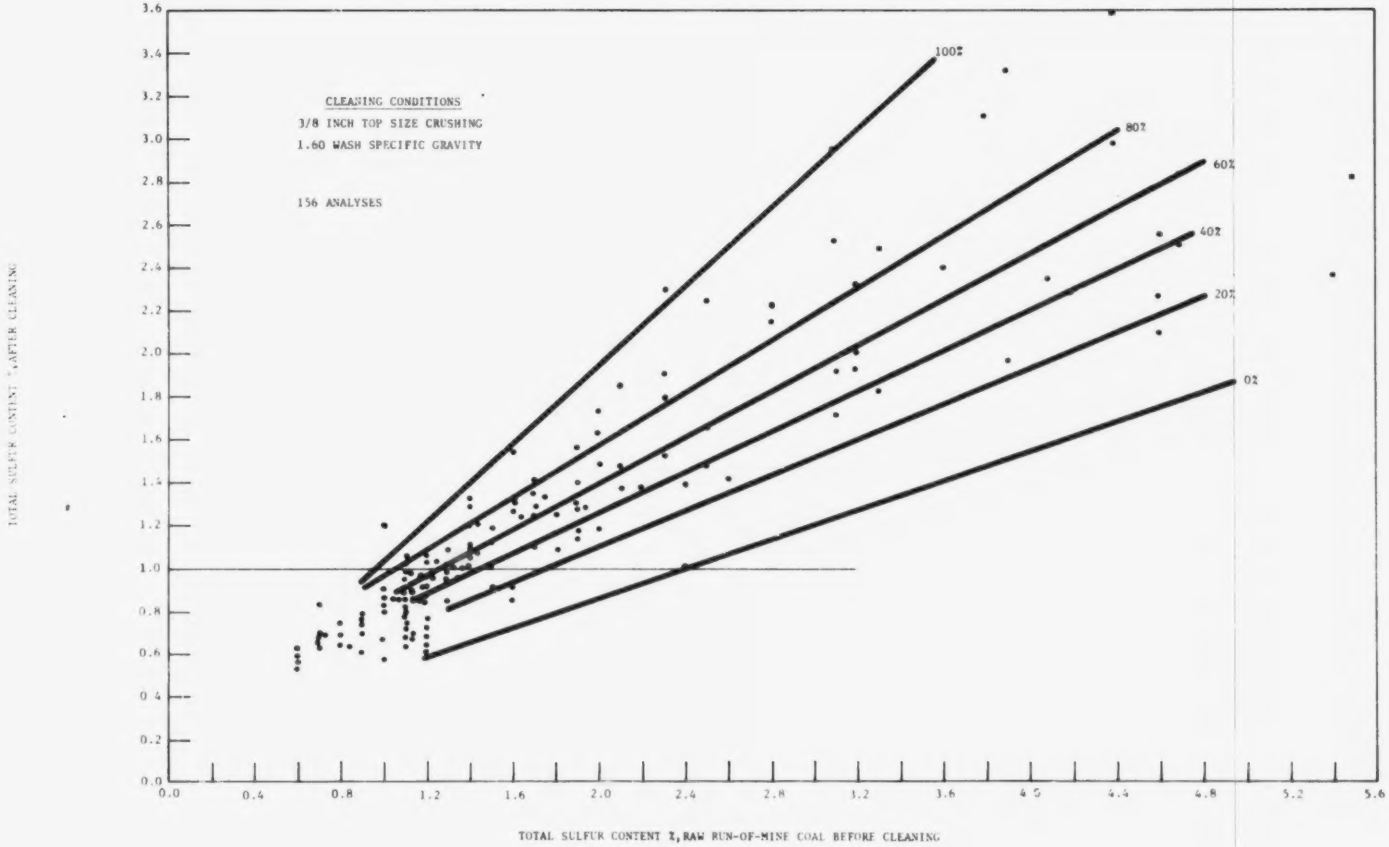

FIGURE I-9
DISTRICTS 7 & 8

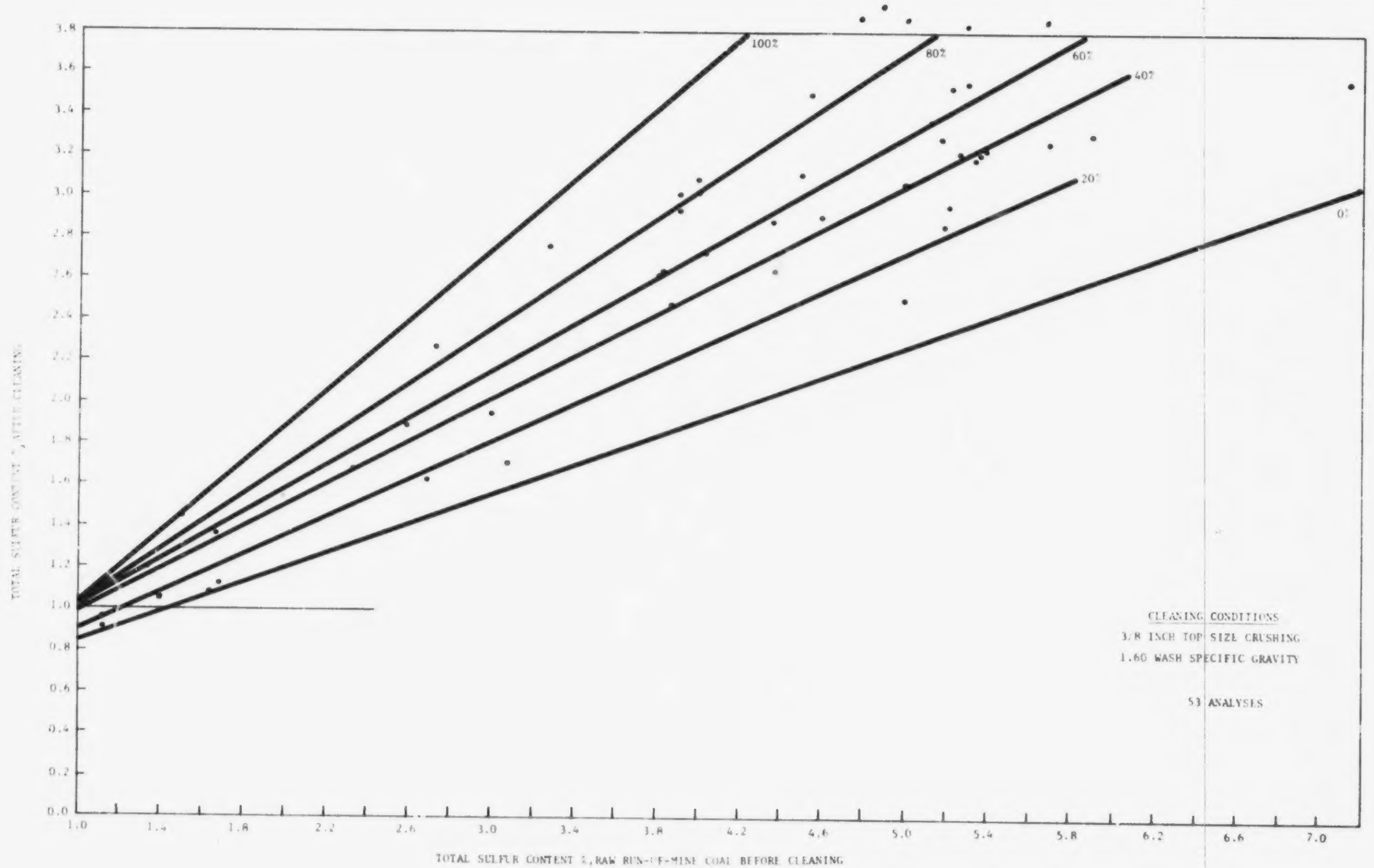

FIGURE I-10
DISTRICT 10

Each figure then indicates, in 20% intervals, the upper bounds containing the corresponding percentage of analyses. Figures I-11 and I-12 summarize the intercepts of these upper bounds with the coordinate corresponding to a total sulfur content after cleaning of 1%. Figure I-11 combines the individual seams of the Allegheny Group which constitute sulfur removal Category I. Upper and lower bounds on the sulfur removal relationship are indicated. Figure I-12 combines those seams or coal producing districts, depending on the availability of cleanability analyses, which constitute sulfur removal Category II. In general, the second category requires a lower raw coal total sulfur content to achieve the required sulfur content after cleaning. These categories are summarized in Table I-1.

TABLE I-1

SULFUR REMOVAL RELATIONSHIPS

Category		Potential Cleanable Coal Sources
I	Defined from Analyses	. Allegheny seam group, Districts 1, 2, 3, Northern Appalachian Region
I	Estimated from Organic Sulfur Content	. District 4, Midwestern Region
II	Defined from Analyses	. Pittsburgh seam, Districts 2 and 3, Northern Appalachian Region
II	Defined from Analyses	. District 7 and 8, Southern Appalachian Region
II	Defined from Analyses	. District 10, Midwestern Region
II	Estimated from Organic Sulfur Content	. District 9, Midwestern Region

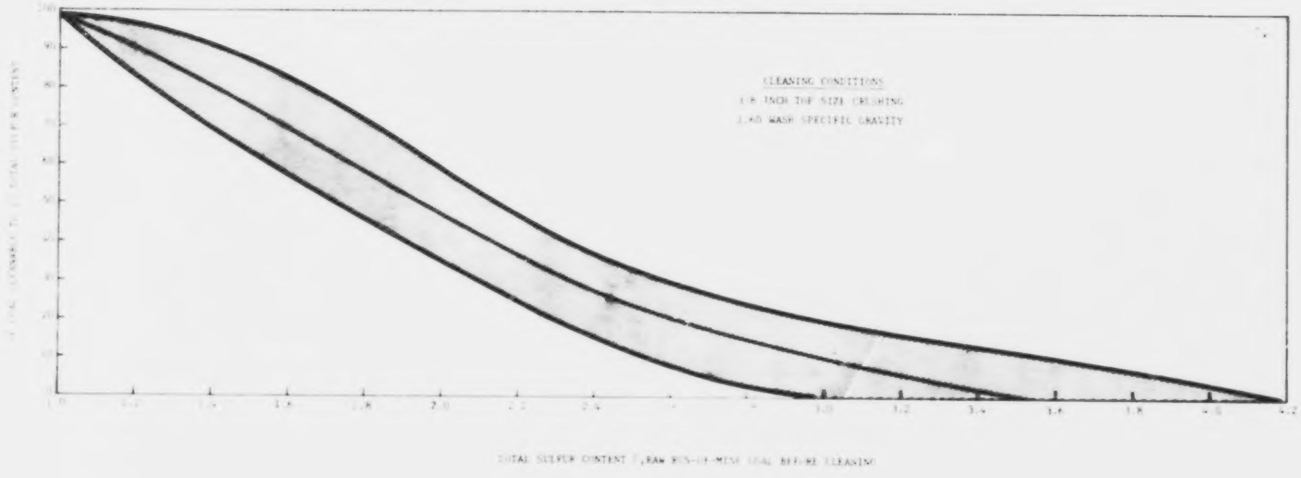

FIGURE I-11
ESTIMATED PHYSICAL CLEANABILITY OF COAL TO 1% SULFUR CONTENT, CATEGORY I
(ALLEGHENY SEAM SERIES)

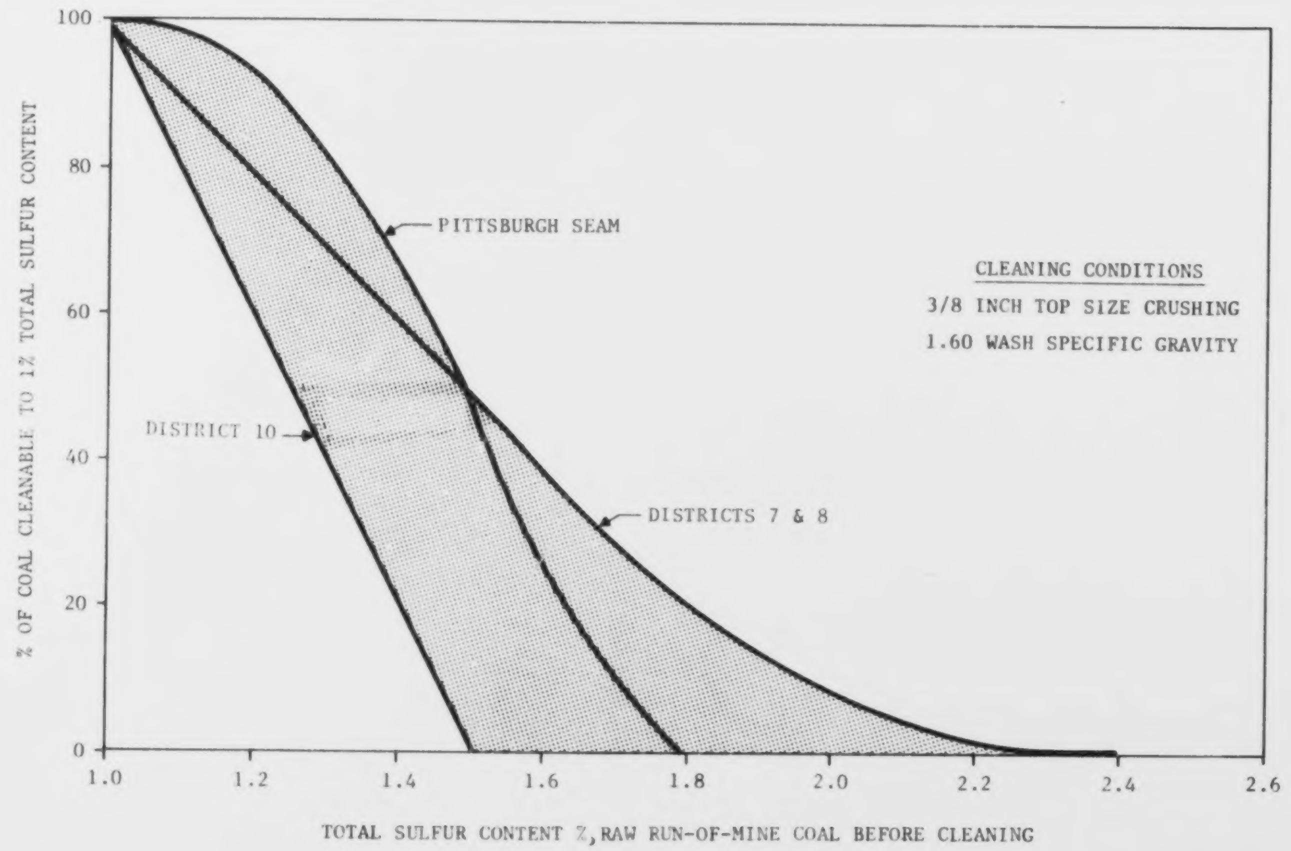

FIGURE I-12

ESTIMATED PHYSICAL CLEANABILITY OF COAL TO ONE PERCENT SULFUR CONTENT-CATEGORY II

These categories, as might be expected, correlate fairly well with the trends in organic sulfur content indicated in Table 4-1. Sources in Category II, which generally indicate a lower percentage of a given sulfur content coal cleanable to 1% than Category I, also indicate a higher percentage of the total sulfur content in the organic form. Thus the degree of pyritic sulfur which must be removed to achieve 1% total sulfur is correspondingly higher in Category II than in Category I. Based on this correlation with organic sulfur content, the remaining districts in the Midwestern Region are divided, with District 4 (Ohio) tentatively assigned to Category I, District 9 (Western Kentucky) to Category II, and District 11 (Indiana) divided between the two categories. Additional cleanability analyses whould be performed in the Midwestern Region, however, including District 4 to confirm this organization.

APPENDIX I

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APPENDIX II

POTENTIAL CLEAN COAL APPLICATION

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APPENDIX II

POTENTIAL CLEAN COAL APPLICATION

1.0 FUEL COST RELATIONSHIPS

In estimating the probable, rather than theoretical, application of coal cleaned to 1% sulfur content, it is useful to compare the delivered cost relationships of the various fossil fuel options available to the utility and industrial markets before and after the introduction of SO_2 emission control regulations.

Figure II-1 describes, in a first order sense, the delivered cost relationship between coal, oil, and natural gas in 1968, prior to the introduction of widespread SO_2 emission control regulations.[1,2,3,4] These relationships have tended to create the current dependence on coal in the states indicated in Figure II-2. Natural gas, for example, is produced primarily in the Far West and Southwest. Although it has relatively low production and transportation cost rates, the transport distance from source to user has limited its economic competitiveness east of the Mississippi. Oil, on the other hand, has been restricted in primary utilization to large metropolitan areas along the East Coast where the low water transport costs of foreign oil imports has created a competitive delivered cost. This cost at an East Coast port or large river barge terminal is the initial or zero distance cost indicated for oil in Figure II-1. Once overland transportation is included in the delivered cost, oil does not currently compete with coal in the Eastern United States.[4]

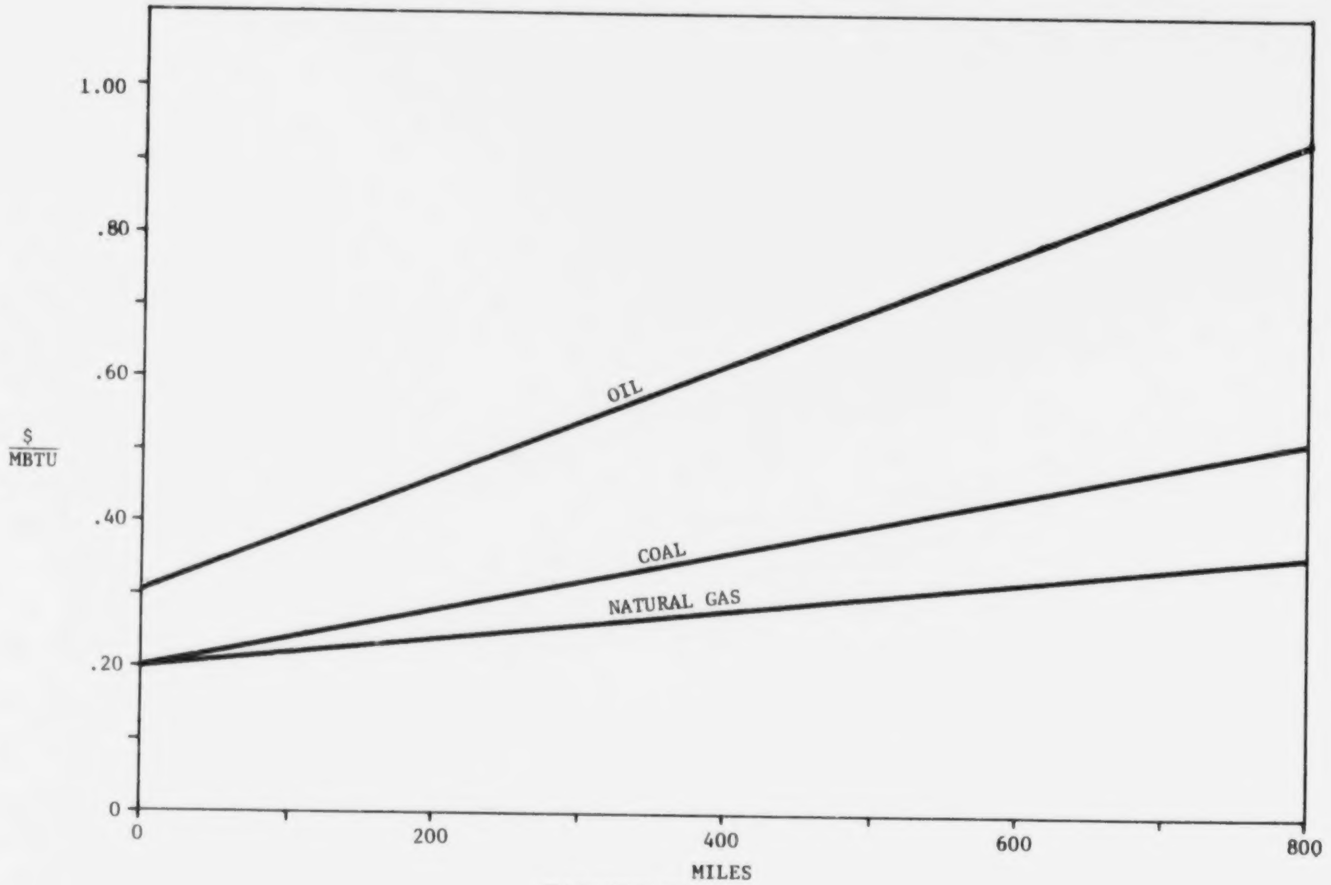

FIGURE II-1
1968 COST RELATIONSHIPS BETWEEN FOSSIL FUEL OPTIONS
FOR INDUSTRIAL AND UTILITY USERS

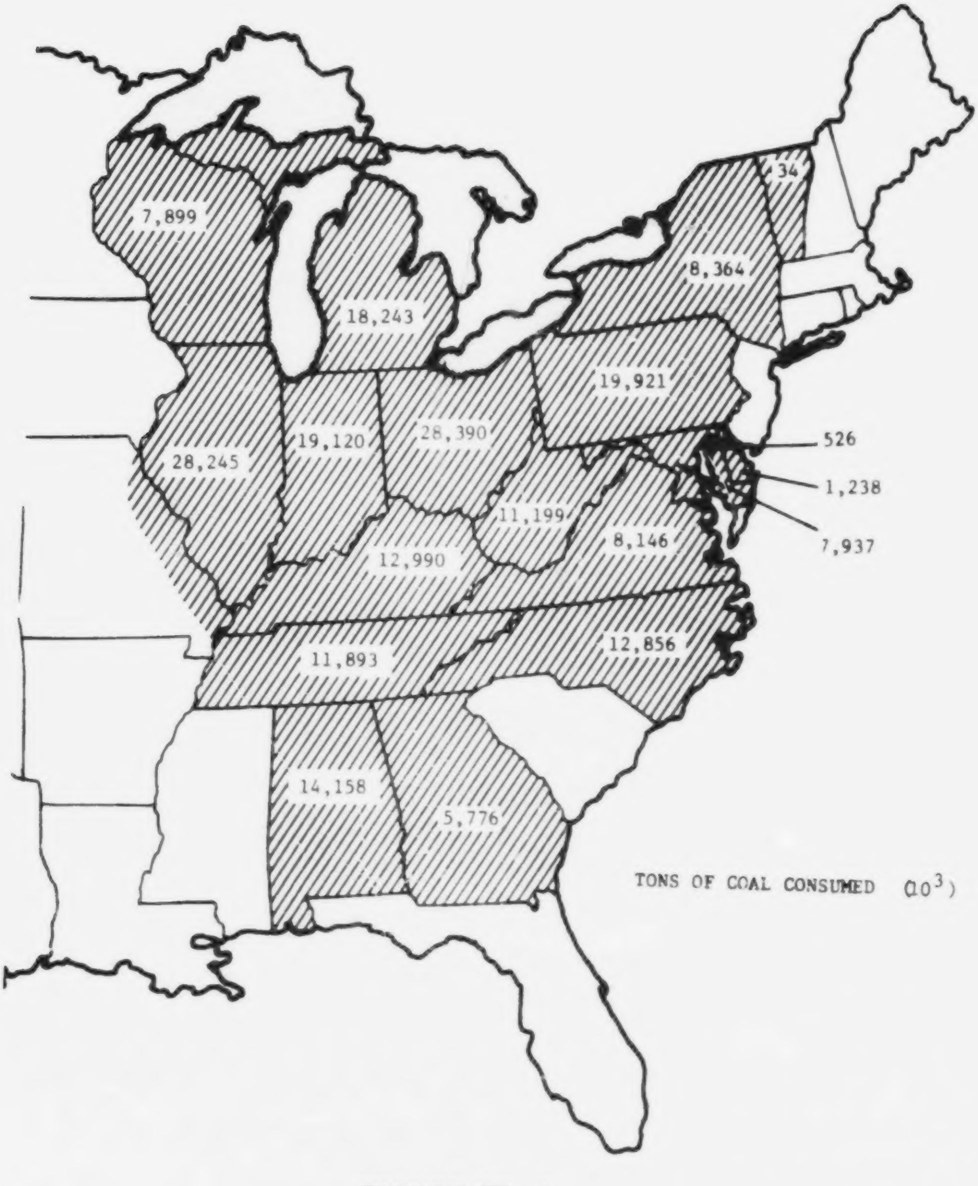

FIGURE II - 2
STATES WHERE COAL PROVIDES 90% OR MORE OF ALL UTILITY AND INDUSTRIAL FUEL COMSUMED

With the introduction of 1% sulfur content in fuel or equivalent SO_2 emission regulations, the cost relationships which the utility and industrial fossil fuel user must consider become considerably more complex. These relationships are indicated, in a first order sense by Figure II-3 for the 1975-1985 time period.[1,2,3,4,5] By 1975, these relationships can be expected to stabilize and create a new equilibrium in utilization between fossil fuel options. The development of Figure II-3 is based on the following assumptions concerning the 1975-1985 time period:

- The application of 1% sulfur content or equivalent SO_2 emission regulations in the Eastern United States will be complete.
- The SO_2 emission control options indicated will be available for commercial application.
- Fossil fuel demands by utility and industrial consumers, will, at a minimum, remain constant.
- Major shifts in the location of utility plants in the Eastern United States will not occur.
- The location of primary fuel sources will not change from present conditions. In the case of oil, this means deep water ports or barge terminals.
- The overland transportation methods currently in use for coal, oil, and gas will not change in a manner to affect relative cost.

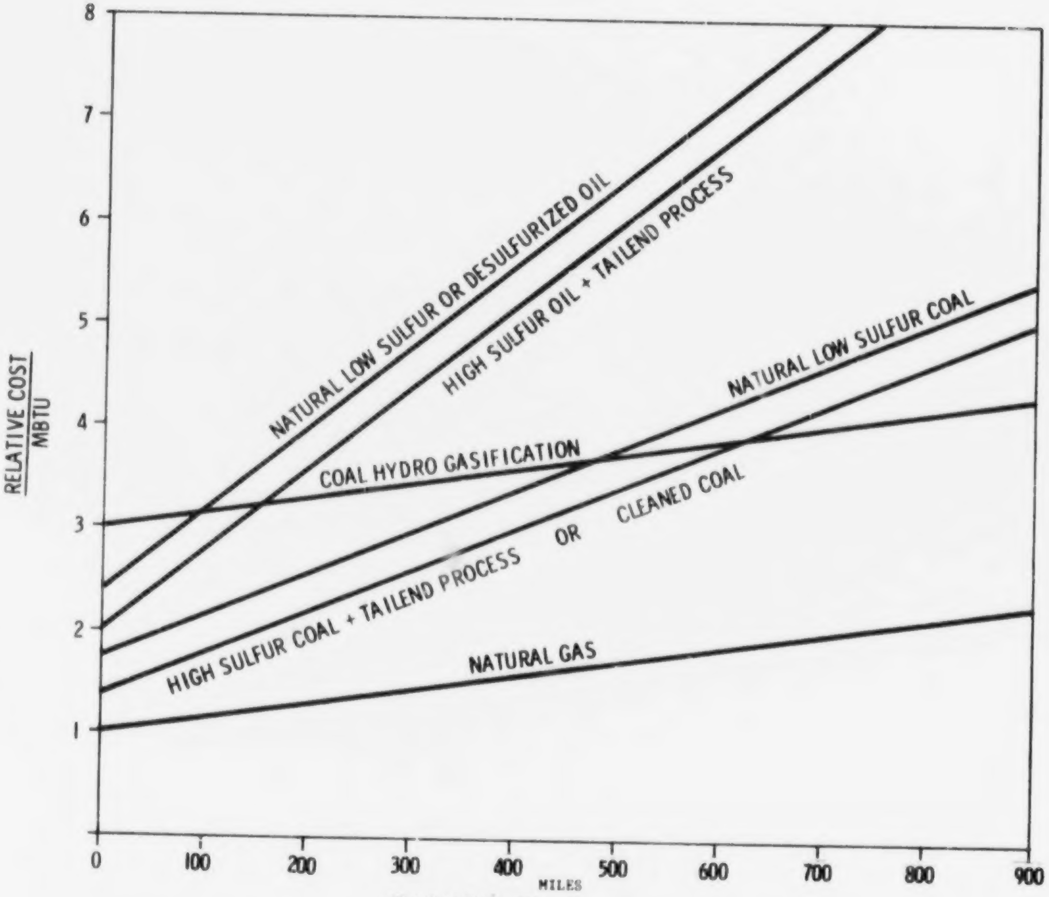

FIGURE II-3
ESTIMATED 1975-1985 COST RELATIONSHIPS BETWEEN SO_2
EMISSION CONTROL OPTIONS

- Utility and industrial consumers will not tend to change the type of fossil fuel consumed unless a clear cut cost advantage can be shown. This limited flexibility is created primarily by plant design considerations which limit fuel specifications and long term fuel contracts.

These assumptions are indicated for the 1975-1985 time period. Beyond this period, reduced confidence in the assumptions, coupled with the possible impact of nuclear power generation, makes the cost relationships questionable. It is emphasized that Figure II-3 represents estimations based on available technology and economic forecasts. The important factor is not the absolute cost attached to each option but rather the cost relationships between options.

2.0 AREAS OF POTENTIAL APPLICATION

Using Figure II-3 and the previously identified fossil fuel source locations, it is possible to determine the geographical marketing areas of the Eastern United States in which the various fossil fuel alternatives would be economically preferred. These marketing areas are indicated in Figure II-4.

Figure II-4 also indicates the emission control option which might be expected to have greatest application in each of the coal marketing areas. This estimate is based both on the sulfur characteristics of the coal sources serving each marketing area and the supply potential of these sources to meet the corresponding fuel demand. In the case of physically desulfurized coal, for example, the area of primary application is considered to be the Northern Appalachian coal marketing area.

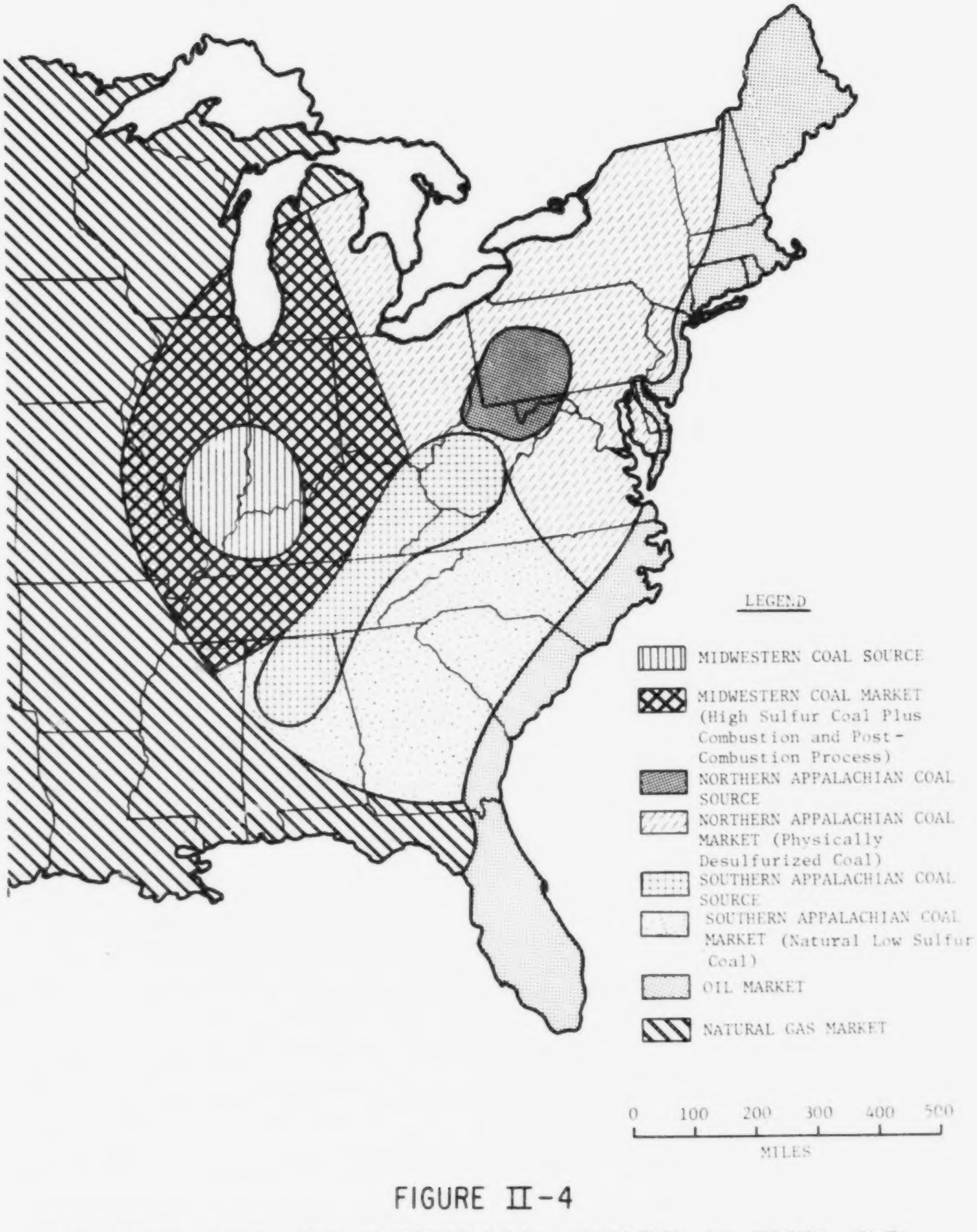
LEGEND
MIDWESTERN COAL SOURCE
MIDWESTERN COAL MARKET (High Sulfur Coal Plus Combustion and Post-Combustion Process)
NORTHERN APPALACHIAN COAL SOURCE
NORTHERN APPALACHIAN COAL MARKET (Physically Desulfurized Coal)
SOUTHERN APPALACHIAN COAL SOURCE
SOUTHERN APPALACHIAN COAL MARKET (Natural Low Sulfur Coal)
OIL MARKET
NATURAL GAS MARKET
0
100
200
300
400
500
MILES

FIGURE II-4

ESTIMATED 1975-1985 GEOGRAPHICAL MARKETS OF FOSSIL FUEL AND ASSOCIATED SO_2 EMISSION CONTROL OPTIONS

Lower fractions of coal production in the Southern Appalachian and Eastern Region appear cleanable to a 1% sulfur level than in the Northern Appalachian Region. As a result, these regions appear most exploitable in terms of natural low sulfur coal and high sulfur coal plus combustion and post-combustion sulfur removal processes respectively and are so indicated in Figure II-4. Further production development of the Illinois and Indiana cleanable coal deposits could, however, provide a significant portion of local coal demands.

The Northern Appalachian coal marketing area, where physically desulfurized coal is expected to have the greatest application as an SO_2 emission control option, has a current utility and industrial coal demand on the order of 110 million tons annually.[5] Thus the Northern Appalachian production of coal cleanable to less than 1% total sulfur must increase about five times to meet the total expected 1975 stationary power source coal demans in its corresponding market area (see Table 4-2).

Unless the coal industry can solve its interrelated cost/production problem based on such factors as the shortage of miners for underground operations, the provisions of the recent Mine Safety Law, and the unstable union-management relationship, its ability to react to the changing coal demands forced by the SO_2 emission regulations is severely limited. In the face of these problems, a five-fold increase in cleanable coal production appears highly unlikely by 1975. As a result, the majority of coal burning stationary power sources in the clean coal ecomonically preferred area will be forced to introduce combustion or post-combustion sulfur removal processes or switch to other fossil fuels.

The limited supply potential of coal physically desulfurized to 1% sulfur content may most logically result in this fuel being primarily used in older stationary power plants in the Northern Appalachian and Midwestern Region coal marketing areas. For the purpose of this study, an "older" stationary power plant is defined as a plant whose present generating units were placed in service prior to 1950. Large pollution control capital equipment investments for units installed prior to 1950 would probably not be considered economically viable by electric utilities or industrial stationary power sources during the 1975-1985 time period for several practical reasons:

- Low plant capacity use factors (less than 50%) occur as the older plants are transferred from base load to peak load service. This reduced production severely penalizes any fixed plant investment but does not affect fuel cost, which is demand responsive.

- The 28 year minimum allowed Internal Revenue Service depreciation period for steam-electric production plants.

- The 5 year minimum allowed Internal Revenue Service depreciation period for pollution control equipment additions.

- High operating and maintenance costs as a result of low heat rate efficiency and low per unit generating capacity. This would promote investment in new more efficient units rather than continued capital modifications.

More than 80% of these older plants are located within the boundaries of incorporated communities. Moreover, 60% are within Census Bureau defined Standard Metropolitan Statistical Areas (SMSA) with populations greater than 100,000 where air pollution concentrations are generally higher.[7] The average annual coal consumption of these older plants is about 500,000 tons.

Since the supply/demand relationship will ultimately determine the market value of coal physically cleaned to a 1% sulfur content, it is interesting to compare the coal consumption requirement of these older stationary power sources with the supply potential developed in Section 4.0. Based on available information, Table II-1 indicates the 1968 coal demand and selected characteristics of electric utility generating units installed prior to 1950.[6] As stated earlier, electric utilities create approximately 75% of the total stationary power source coal demand in the Eastern United States. This coal demand is given by state within the Midwestern and Northern Appalachian Region coal market areas as indicated in Figure II-4. Table II-2 compares this 1968 coal demand with the estimated potential supply of coal physically desulfurized to a 1% sulfur content, as developed in Section 4.0 and based on 1968 coal production. Table II-2 indicates that the estimated potential supply of this coal and the corresponding coal demand of electric generating units installed prior to 1950 are approximately equivalent.

TABLE II-1

COAL REQUIREMENTS OF ELECTRIC POWER GENERATING UNITS INSTALLED PRIOR TO 1950

STATE	NUMBER OF PLANTS	COAL CONSUMED 1968 (1000 TONS)	AVERAGE PLANT HEAT RATE (BTU/KWHr)	AVERAGE INITIAL YEAR OF PLANT OPERATION	AVERAGE UNIT GENERATING CAPACITY (MW)
NORTHERN APPALACHIAN REGION COAL MARKET[6]					
MD.	6	2,117	13,334	1929	40
MICH (E.)	6	4,197	12,072	1926	56
N. J.	3	1,188	11,520	1930	57
N. Y.	9	2.950	12,199	1937	49
OHIO (E.)	6	3,017	12,746	1933	49
PA.	13	7,517	14,135	1930	55
VA.	4	2,093	11,990	1930	56
W. VA. (N.)	2	1,113	14,022	1918	34
	49	24,192			
MIDWESTERN REGION COAL MARKET [6]					
ILL.	8	3,860	12,218	1936	52
IND.	7	3,718	12,459	1933	54
KY. (W.)	2	863	12,067	1946	60
MICH. (W.)	1	308	12,342	1939	46
OHIO	6	3,646	12,131	1929	52
	24	12,395			

TABLE II-2

ESTIMATED POTENTIAL SUPPLY OF 1% SULFUR CONTENT PHYSICALLY DESULFURIZED COAL
AND
THE ELECTRIC UTILITY COAL DEMAND FOR UNITS INSTALLED PRIOR TO 1950

(Based on 1968 Coal Production and 1968 Electric Utility Coal Consumption)

NORTHERN APPALACHIAN REGION COAL MARKET	
ESTIMATED POTENTIAL SUPPLY (1000 TONS)	25,500 - 38,000
ESTIMATED DEMAND[6] (1000 TONS)	24,192
MIDWESTERN REGION COAL MARKET	
ESTIMATED POTENTIAL SUPPLY (1000 TONS)	7,600 - 11,400
ESTIMATED DEMAND[6] (1000)	12,395

This supply/demand equivalence is indicative, in a first order sense, that the coal needs of these older stationary power sources, particularly in the Northern Appalachian Region coal market, could be satisfied by physically desulfurized coal of 1% sulfur content without extensive additional raw coal mine production or new competition within domestic coal markets.

The results of this preliminary examination suggest that detailed economic "system" analyses be performed to relate physically desulfurized coal to other SO_2 emission control alternatives. Areas to be considered should include plant capacity use factors and other markets for low sulfur coal.

In this manner, a forecast of the actual market price of 1% sulfur content physically desulfurized steam coal could be developed, giving the coal industry and stationary power plants perspective on which to plan future coal production and utilization.

APPENDIX II

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AMORTIZATION PAYMENT DATA

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Figure III-7 Self-Liquidating Yearly Mortgage Payments Per Ton Hour Plant Input Capacity. Plant Cost of $15,000/Ton Hour Input Capacity 173

APPENDIX III

AMORTIZATION PAYMENT DATA

This appendix indicates cleaning plant self-liquidating - yearly mortgage payments per ton hour plant input capacity. These values are provided for various plant costs and unpaid balance interest rates. The data are presented both in table and graph form.

TABLE III-1

SELF-LIQUIDATING MORTGAGE PAYMENT (IN DOLLARS) PER $1000 OF LOAN
YEARLY COST--BASED ON EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9%	9-1/2%
Loan Period (Yrs.)						
8	157.79	163.69	169.72	172.78	175.88	179.00
10	133.31	139.41	145.67	148.86	152.08	155.35
12	117.18	123.48	129.97	133.28	136.63	140.03
15	101.34	107.93	114.75	118.23	121.78	125.37
20	86.04	93.10	100.44	104.20	108.03	111.92

TABLE III-2

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON
HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF
$3,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9	9-1/2%
Loan Period (Yrs.)						
8	473.37	491.07	509.16	518.34	527.64	537.00
10	399.93	418.23	437.01	446.58	456.24	466.05
12	351.54	370.44	389.91	399.84	409.89	420.09
15	304.02	323.79	344.25	354.69	365.34	376.11
20	258.12	279.30	301.32	312.60	324.09	335.76

TABLE III-3

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON
HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF
$5,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9	9-1/2%
Loan Period (Yrs.)						
8	788.95	818.45	848.60	863.90	879.40	895.00
10	666.55	697.05	728.35	744.30	760.40	776.75
12	585.90	617.40	649.85	666.40	683.15	700.15
15	506.70	539.65	573.75	591.15	608.90	626.85
20	430.20	465.50	502.20	521.00	540.15	559.60

TABLE III-4

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF $8,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9%	9-1/2%
Loan Period (Yrs.)						
8	1262.32	1309.52	1357.76	1382.24	1407.04	1432.00
10	1066.48	1115.28	1165.36	1190.88	1216.64	1242.80
12	937.44	987.84	1039.76	1066.24	1093.04	1120.24
15	810.72	863.44	918.00	945.84	974.24	1002.96
20	688.32	744.80	803.52	833.60	864.24	895.36

TABLE III-5

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF $10,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9%	9-1/2%
Loan Period (Yrs.)						
8	1577.90	1636.90	1697.20	1727.80	1758.80	1790.00
10	1333.10	1394.10	1456.70	1488.60	1520.80	1553.50
12	1171.80	1234.80	1299.70	1332.80	1366.30	1400.30
15	1013.40	1079.30	1147.50	1182.30	1217.80	1253.70

TABLE III-6

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF $12,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate	6%	7%	8%	8-1/2%	9%	9-1/2%
Loan Period (Yrs.)						
8	1893.48	1964.28	2036.64	2073.36	2110.56	2148.00
10	1599.72	1672.92	1748.04	1786.32	1824.96	1864.20
12	1406.16	1481.76	1559.64	1599.36	1639.56	1680.36
15	1216.08	1295.16	1377.00	1418.76	1461.36	1504.44
20	1032.48	1117.20	1205.28	1250.40	1296.36	1343.04

TABLE III-7

SELF-LIQUIDATING YEARLY MORTGAGE PAYMENT (IN DOLLARS) PER TON HOUR PLANT INPUT CAPACITY. PAYMENTS BASED ON PLANT COST OF $15,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

Interest Rate						
Loan Period (Yrs.)	6%	7%	8%	8-1/2%	9%	9-1/2%
8	2366.85	2455.35	2545.80	2591.70	2638.20	2685.00
10	1999.65	2091.15	2185.05	2232.90	2281.20	2330.25
12	1757.70	1852.20	1949.55	1999.20	2049.45	2100.45
15	1520.10	1618.95	1721.25	1773.45	1826.70	1880.25
20	1290.60	1396.50	1506.60	1563.00	1620.45	1678.80

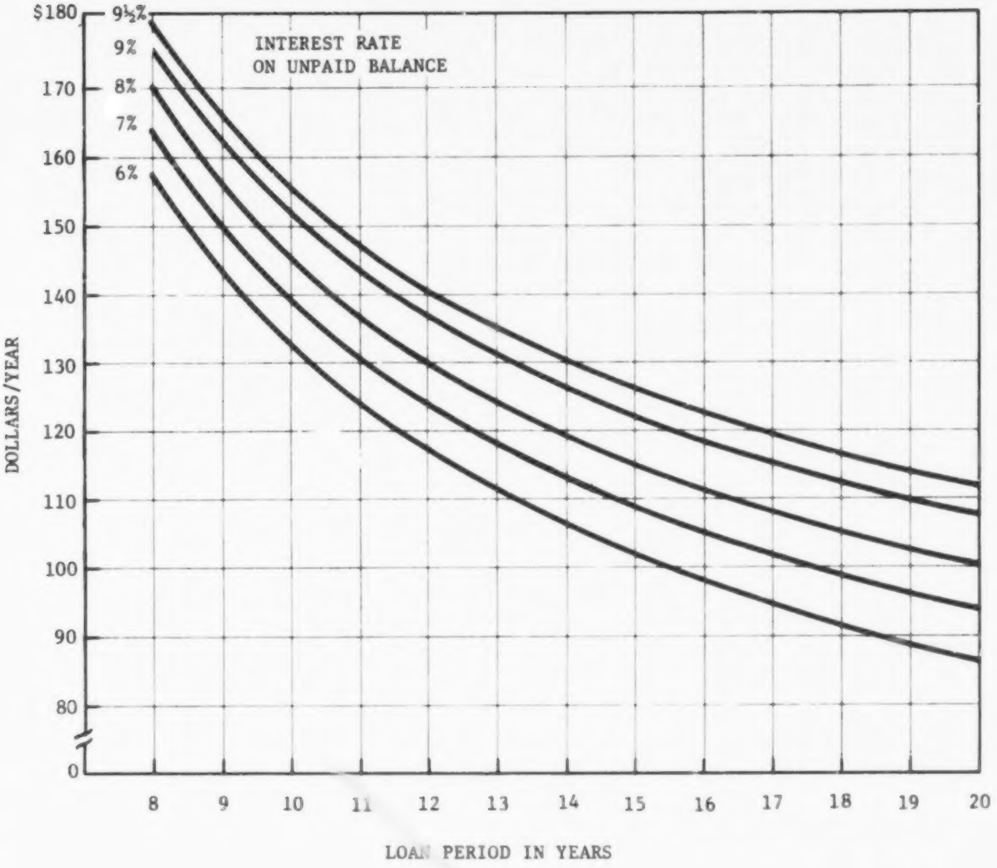


FIGURE III-1
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $1,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

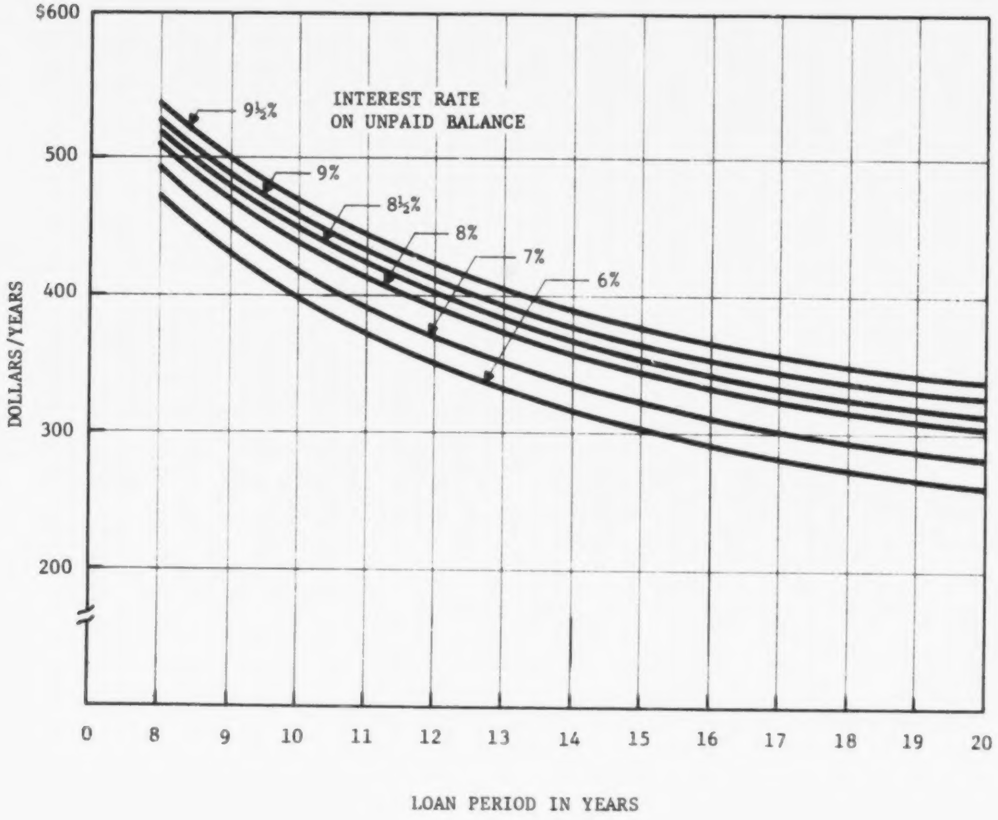
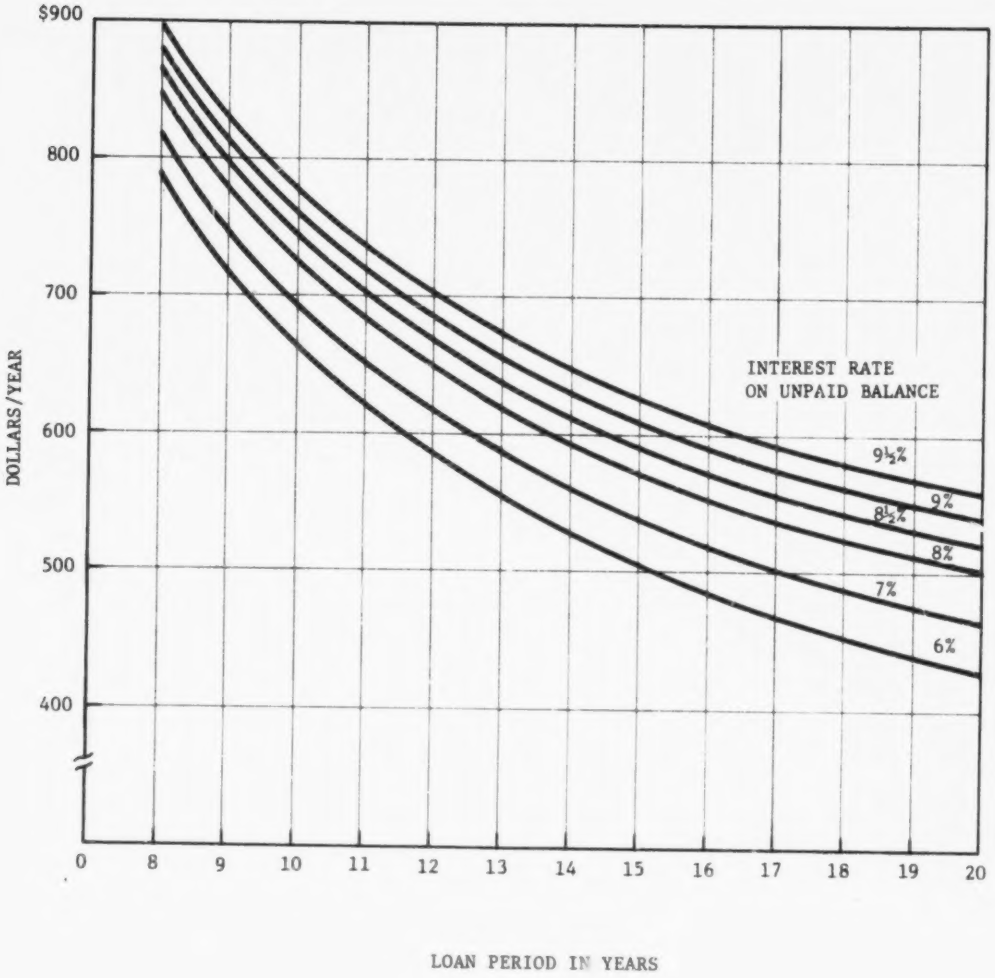


FIGURE III-2
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $3,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS



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SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $5,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

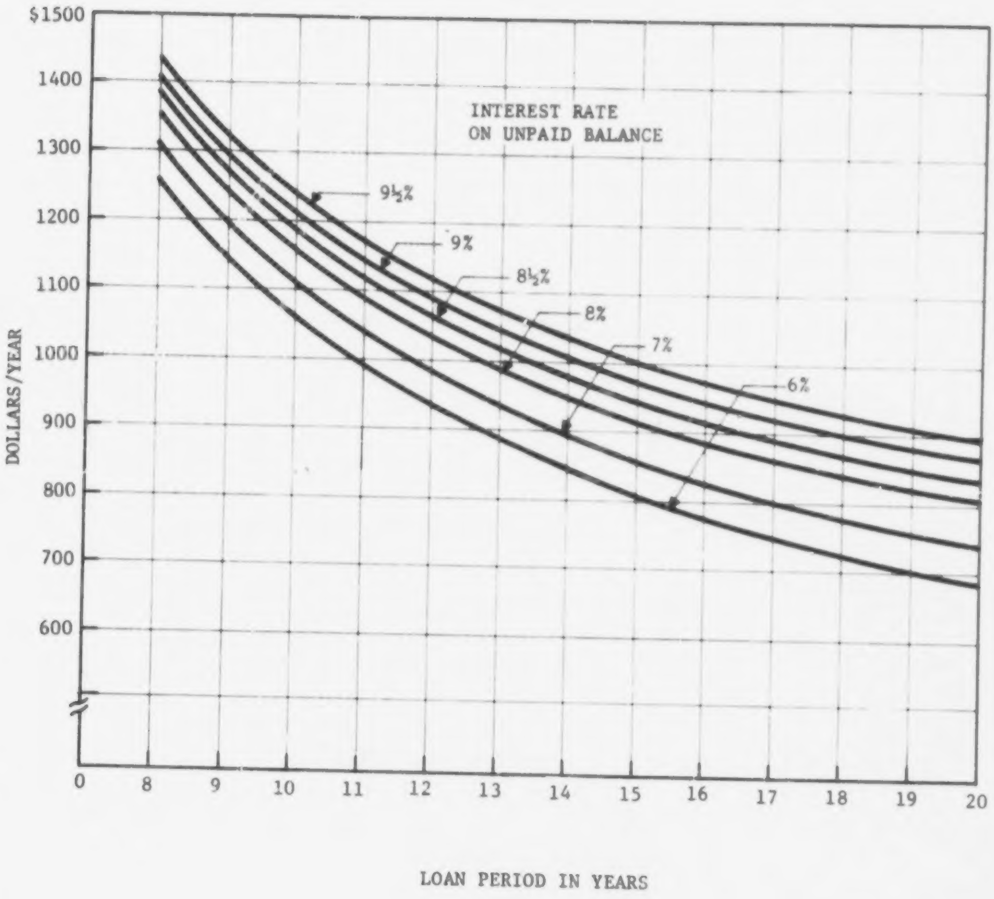

FIGURE III-4
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $8,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

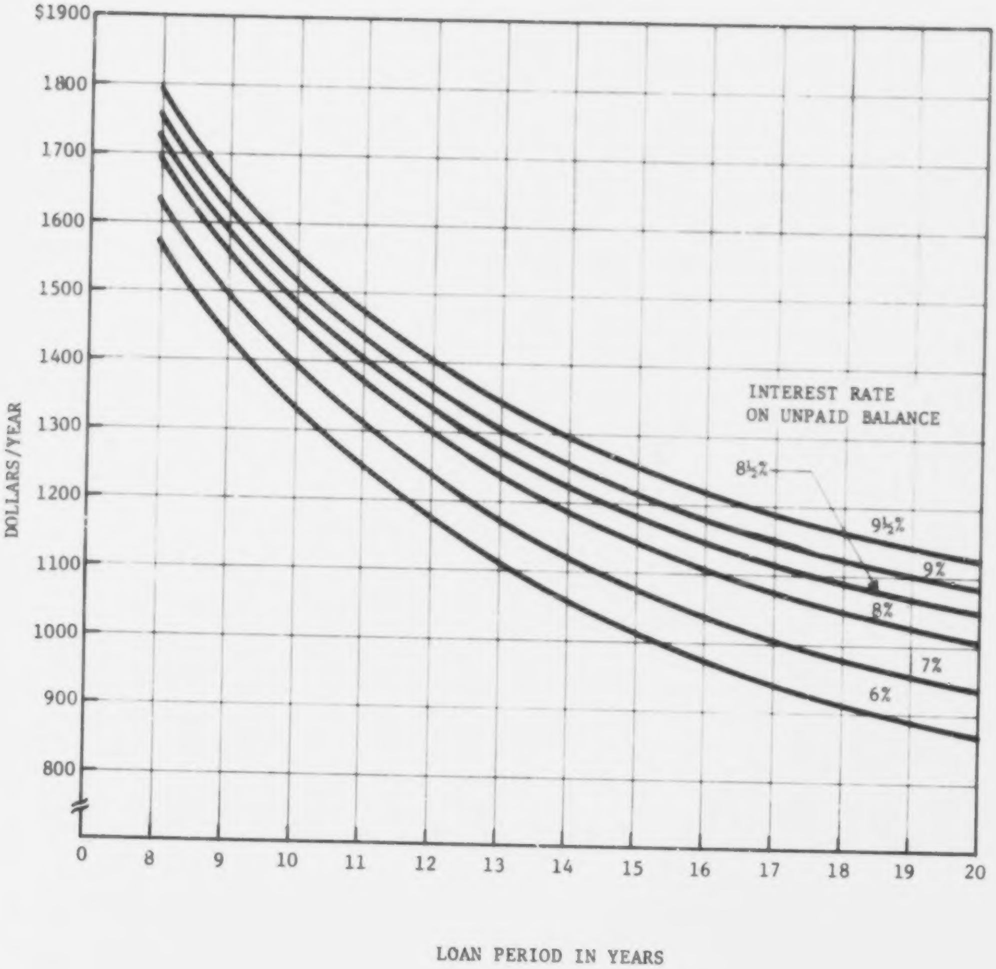

FIGURE III-5
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $10,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

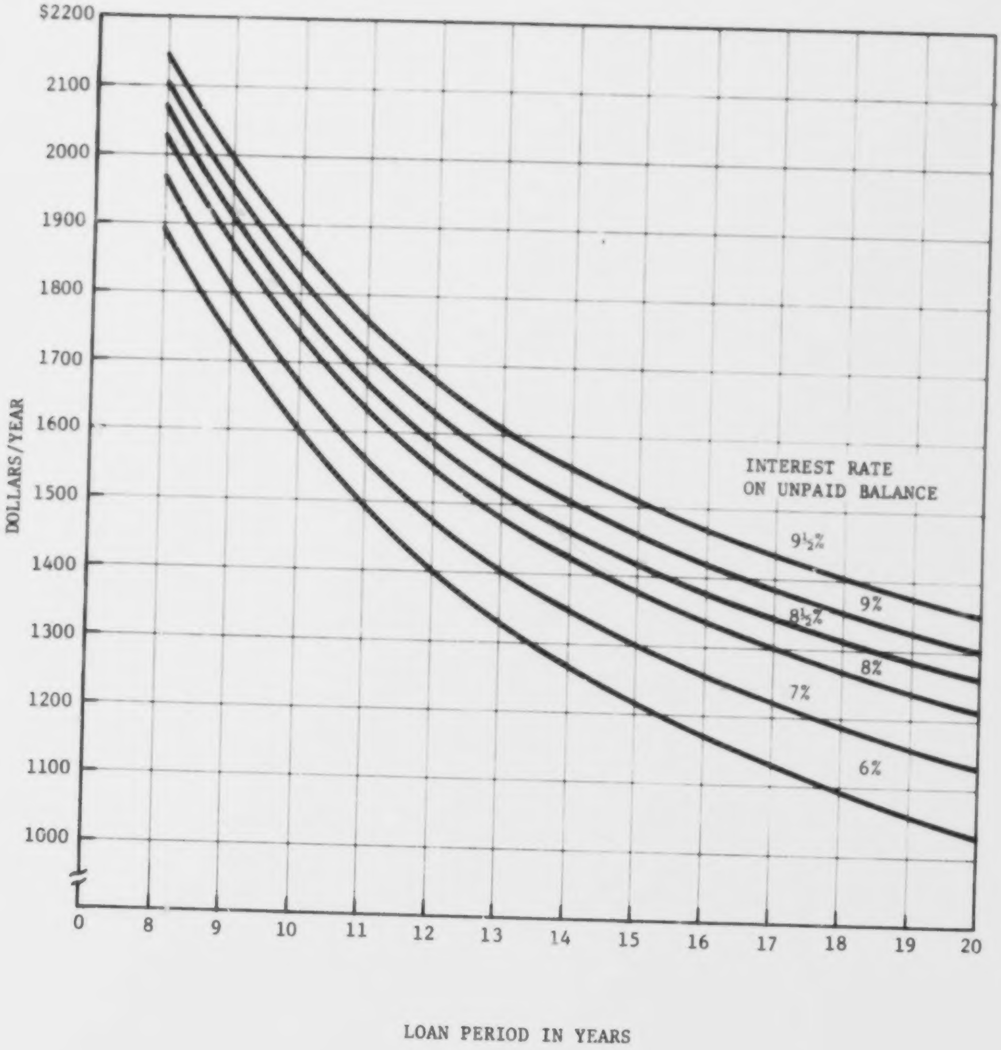

FIGURE III-6
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $12,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

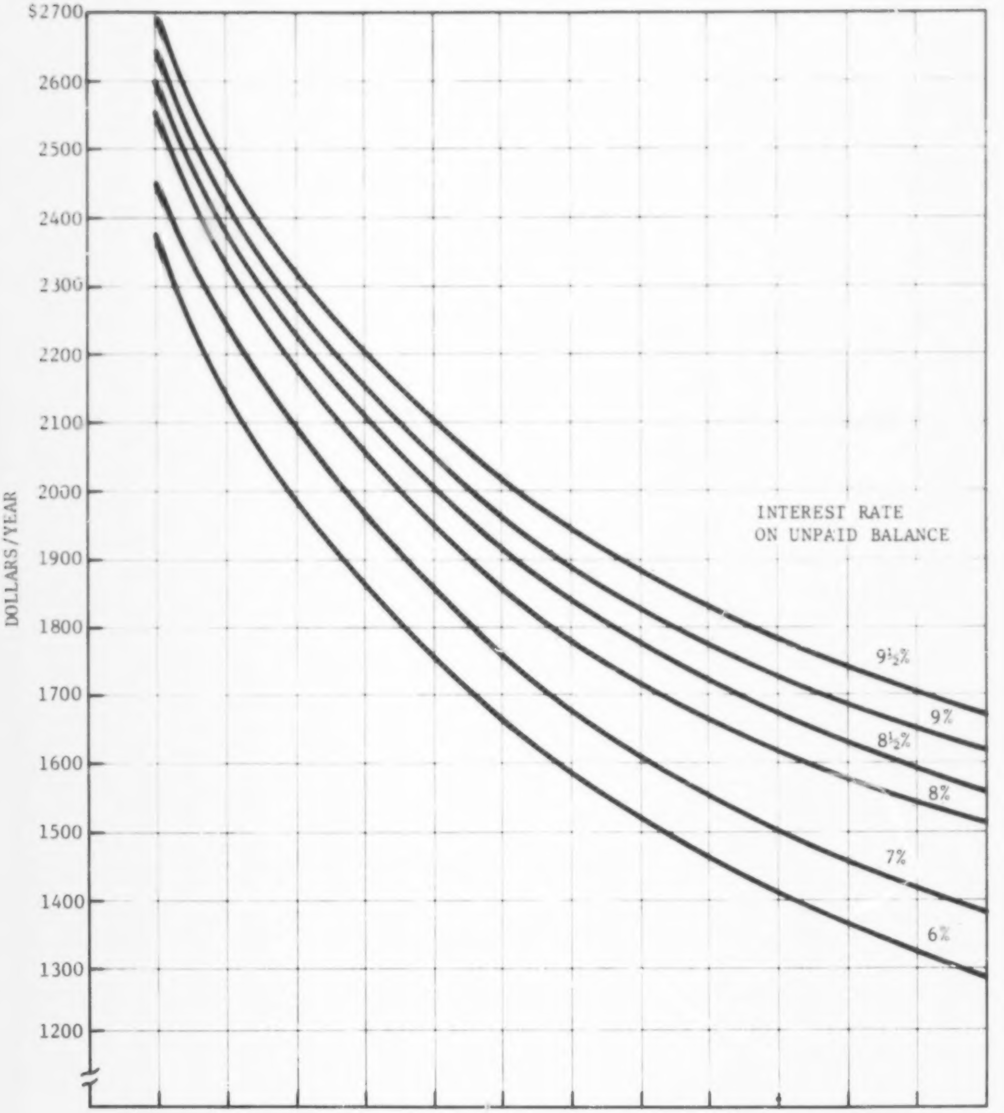

FIGURE III-7
SELF-LIQUIDATING YEARLY MORTGAGE PAYMENTS PER TON HOUR PLANT INPUT CAPACITY. COSTS BASED ON PLANT COST OF $15,000 PER TON HOUR INPUT CAPACITY AND EQUAL MONTHLY PAYMENTS

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CLEANING PLANT UTILIZATION AND AMORTIZATION FUNCTIONS

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APPENDIX IV

CLEANING PLANT UTILIZATION AND AMORTIZATION FUNCTIONS

Figure IV-1 indicates the percent of cleaning plant utilization as a function of operating hours per year (assuming plant operates at capacity).

Figures IV-2 through IV-19 indicate the range of cleaning plant amortization costs per ton of coal cleaned as a continual function of plant utilization, plant cost, interest rate (on unpaid balance), and plant yield. All curves are based on the accepted Internal Revenue Service ten-year amortization period.

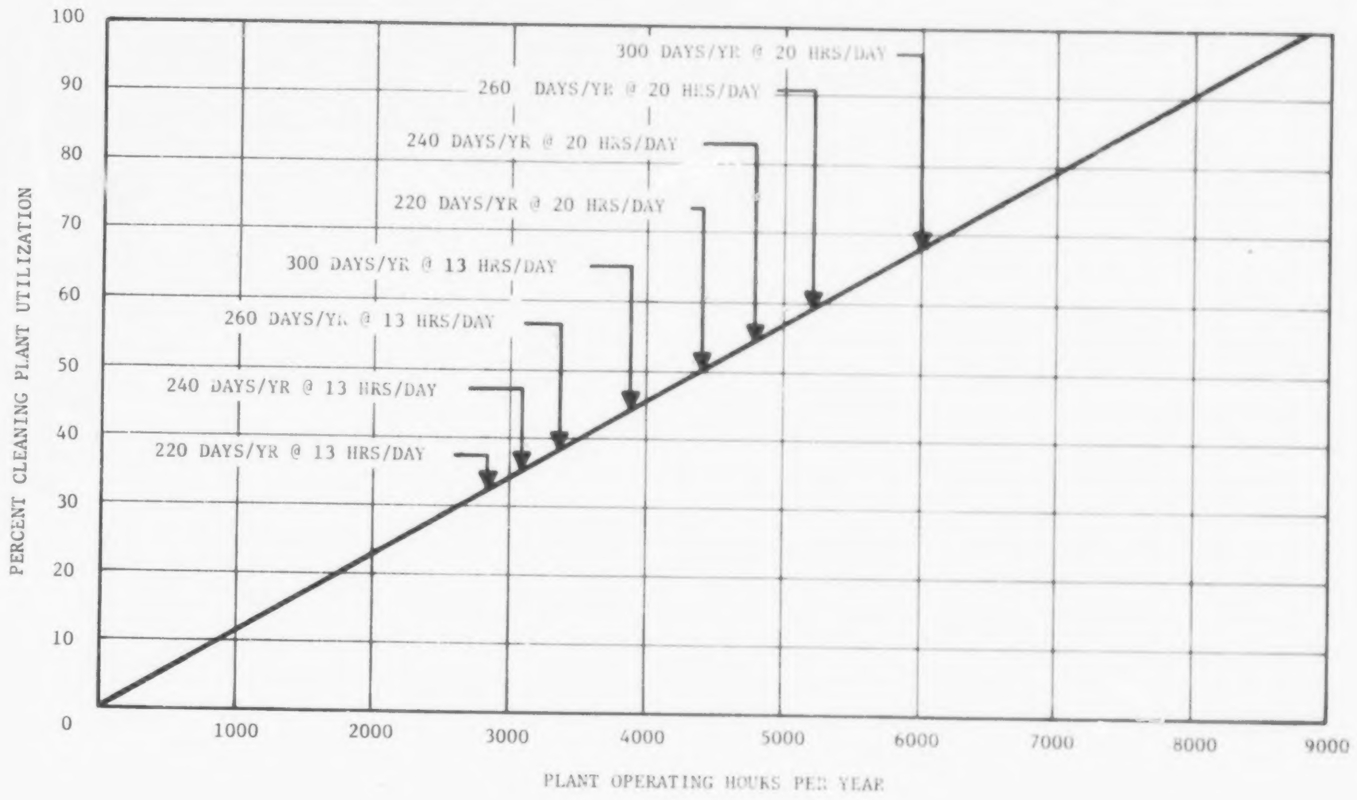

FIGURE IV-1
CLEANING PLANT UTILIZATION

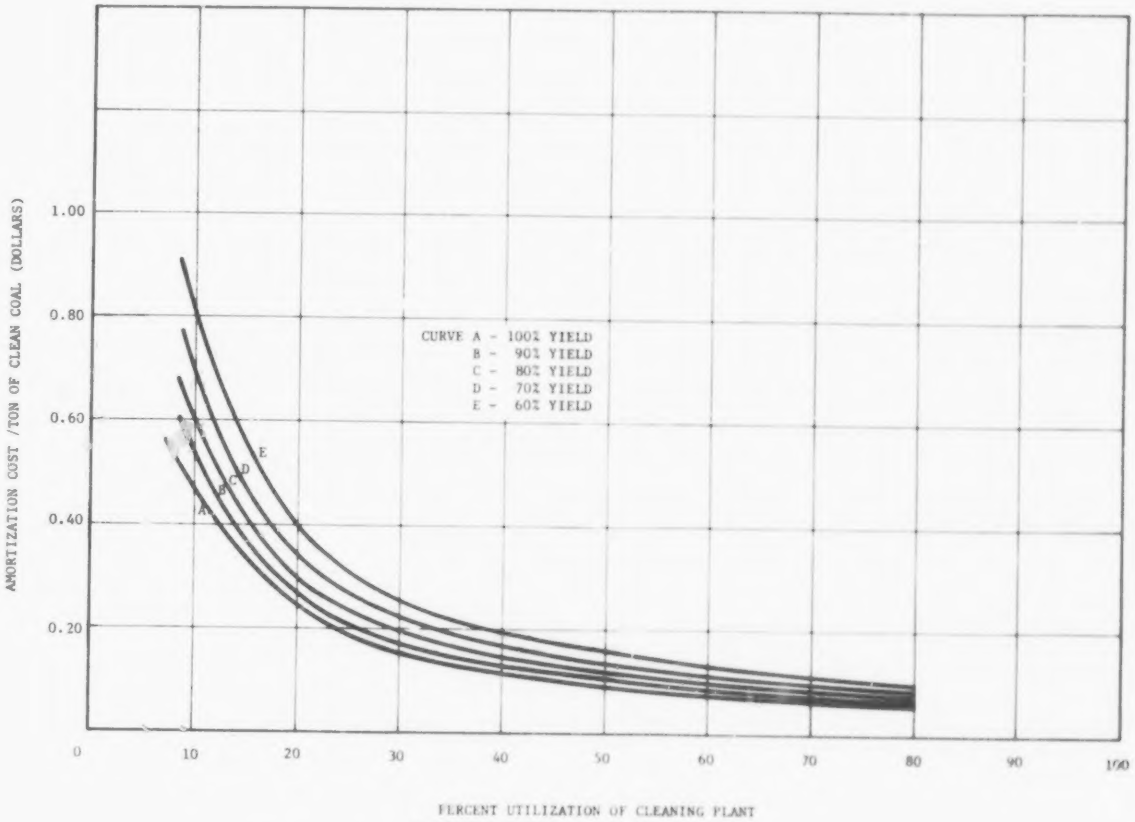

FIGURE IV-2
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $ 3,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 7% LOAN PERIOD - 10 YEARS

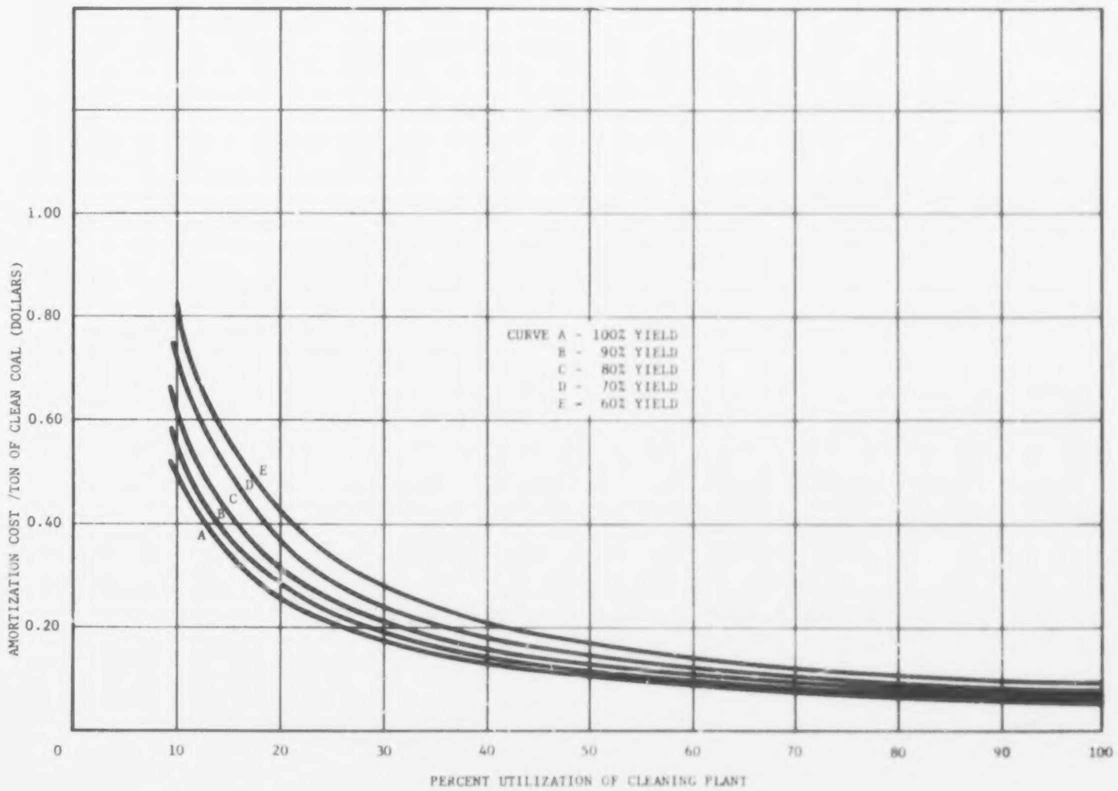

FIGURE IV-3
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $3,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8% LOAN PERIOD - 10 YEARS

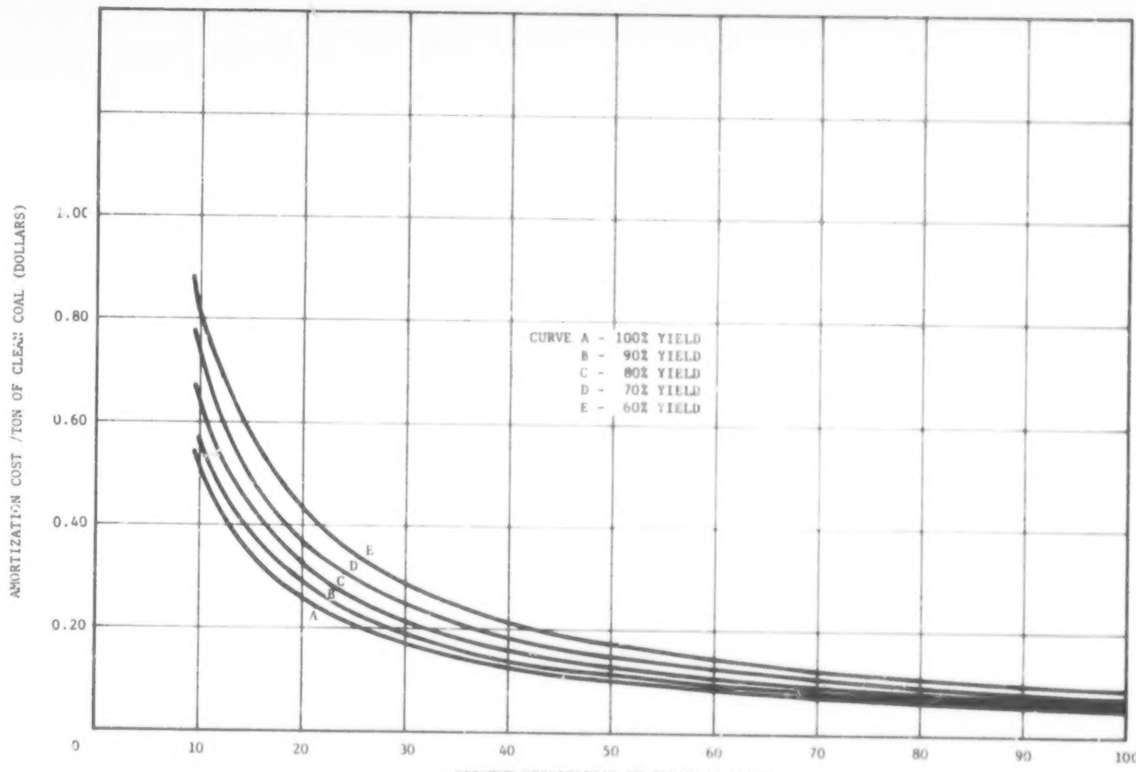

FIGURE IV-4
AMORTIZATION COST / TON CLEANED COAL

FOR:

PLANT COST $3,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 9% LOAN PERIOD - 10 YEARS

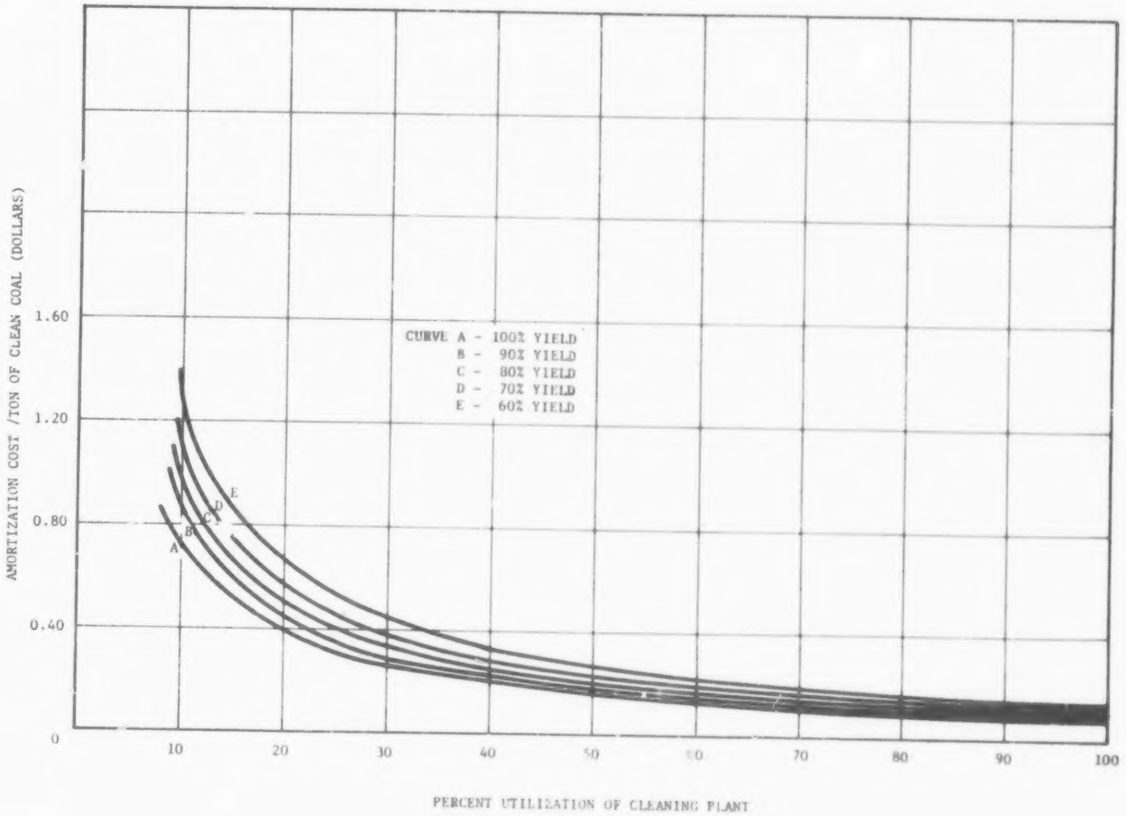

FIGURE IV-5

AMORTIZATION COST / TON CLEANED COAL

FOR:

PLANT COST - $ 5,000 PER TON HOUR INPUT CAPACITY

INTEREST RATE - 7% LOAN PERIOD - 10 YEARS

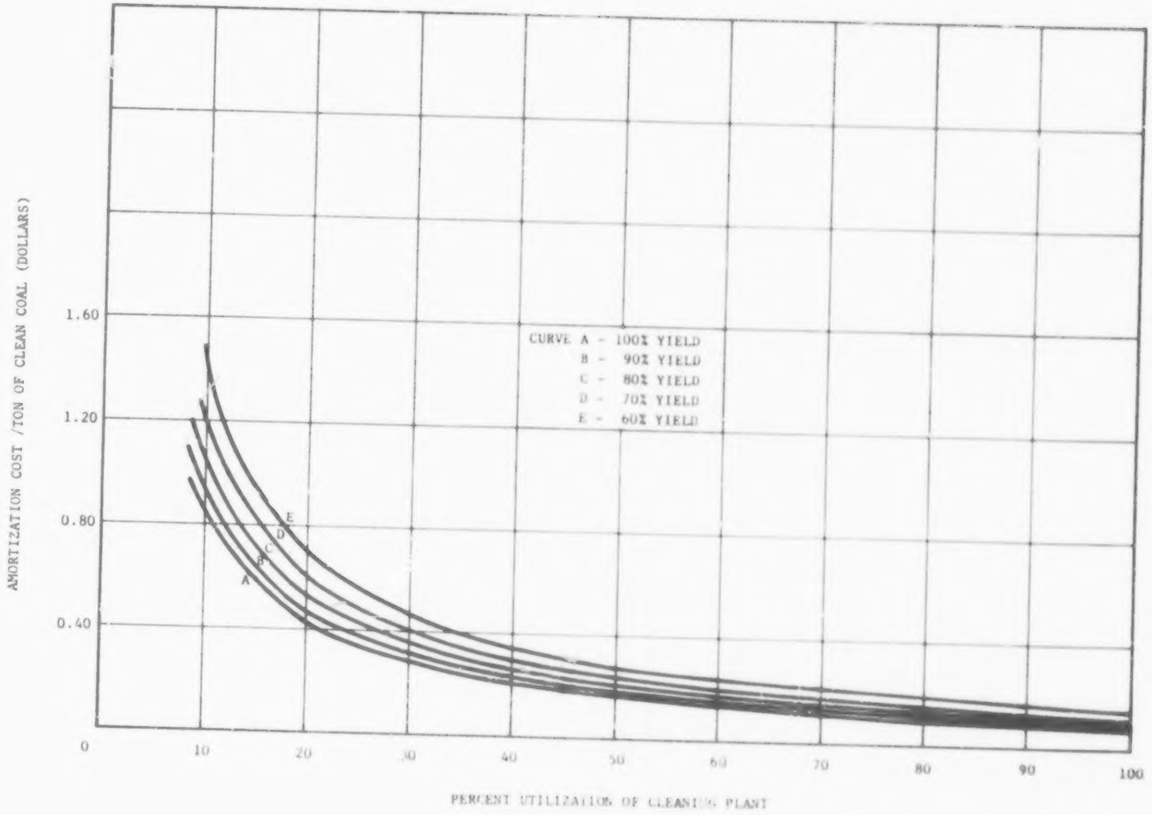

FIGURE IV-6
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $ 5,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8 % LOAN PERIOD - 10 YEARS

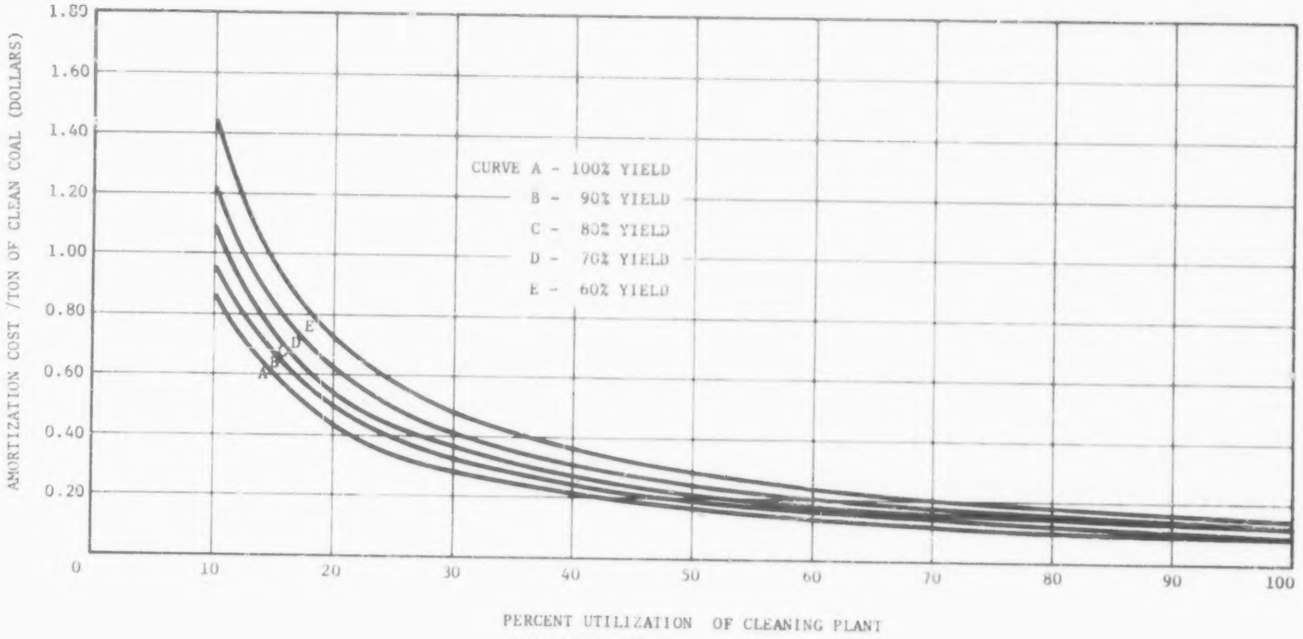

FIGURE IV-7

AMORTIZATION COST / TON CLEANED COAL

FOR:

PLANT COST - $ 5,000 PER TON HOUR INPUT CAPACITY

INTEREST RATE - 9% LOAN PERIOD - 10 YEARS

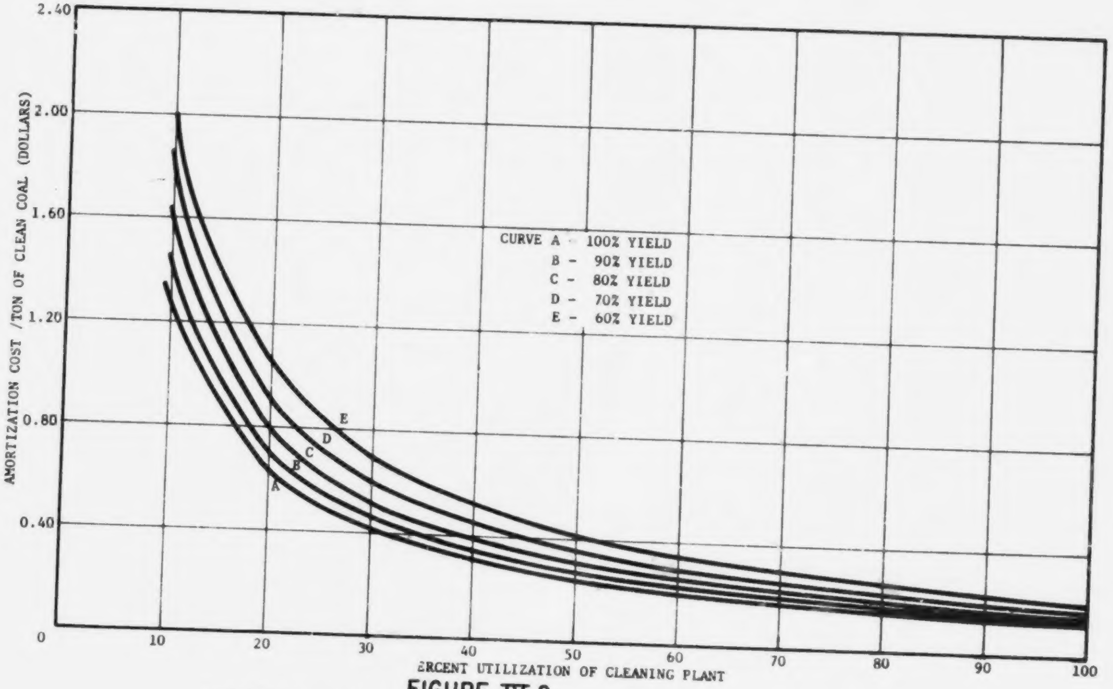

FIGURE IV-8
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $8,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 7 % LOAN PERIOD-10 YEARS

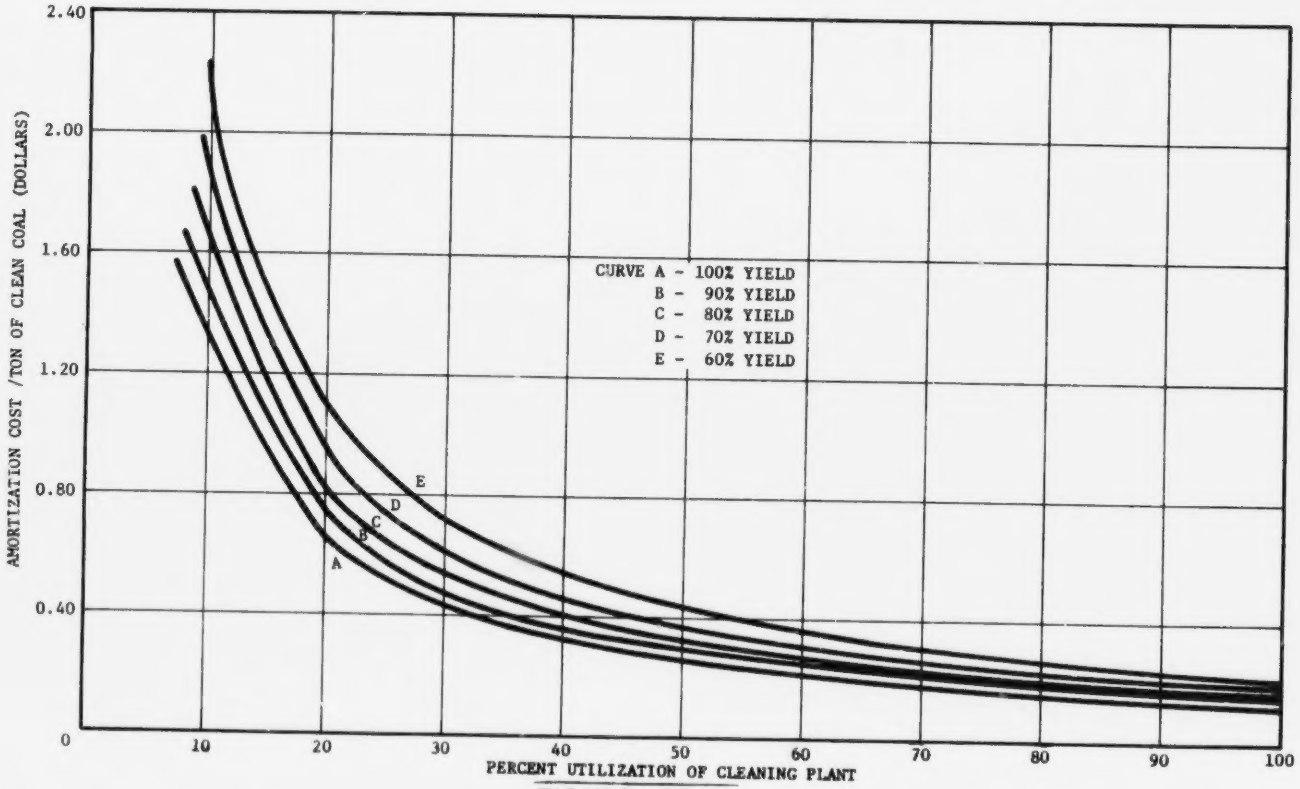

FIGURE IV-9
AMORTIZATION COST / TON CLEANED COAL
FOR:

PLANT COST - $8,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8 %. LOAN PERIOD - 10 YEARS

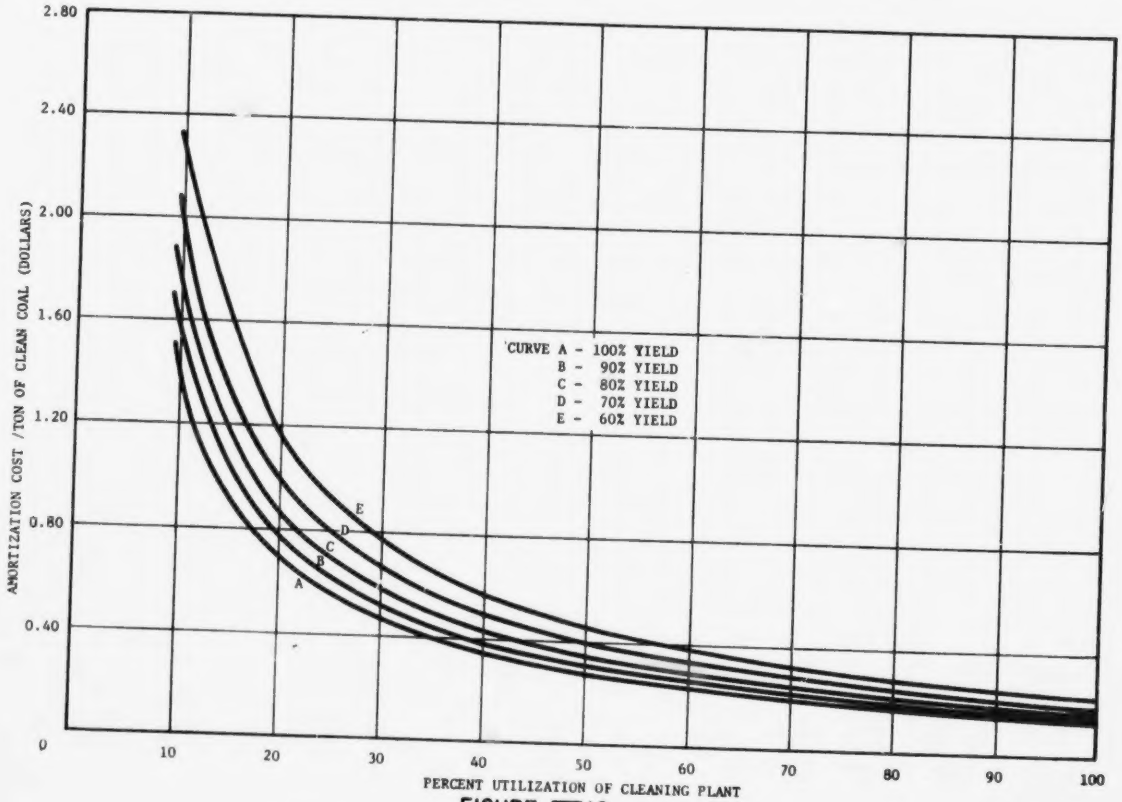

FIGURE IV-10

AMORTIZATION COST / TON CLEANED COAL

FOR :

PLANT COST - $8,000 PER TON HOUR INPUT CAPACITY

INTEREST RATE - 9% LOAN PERIOD-10 YEARS

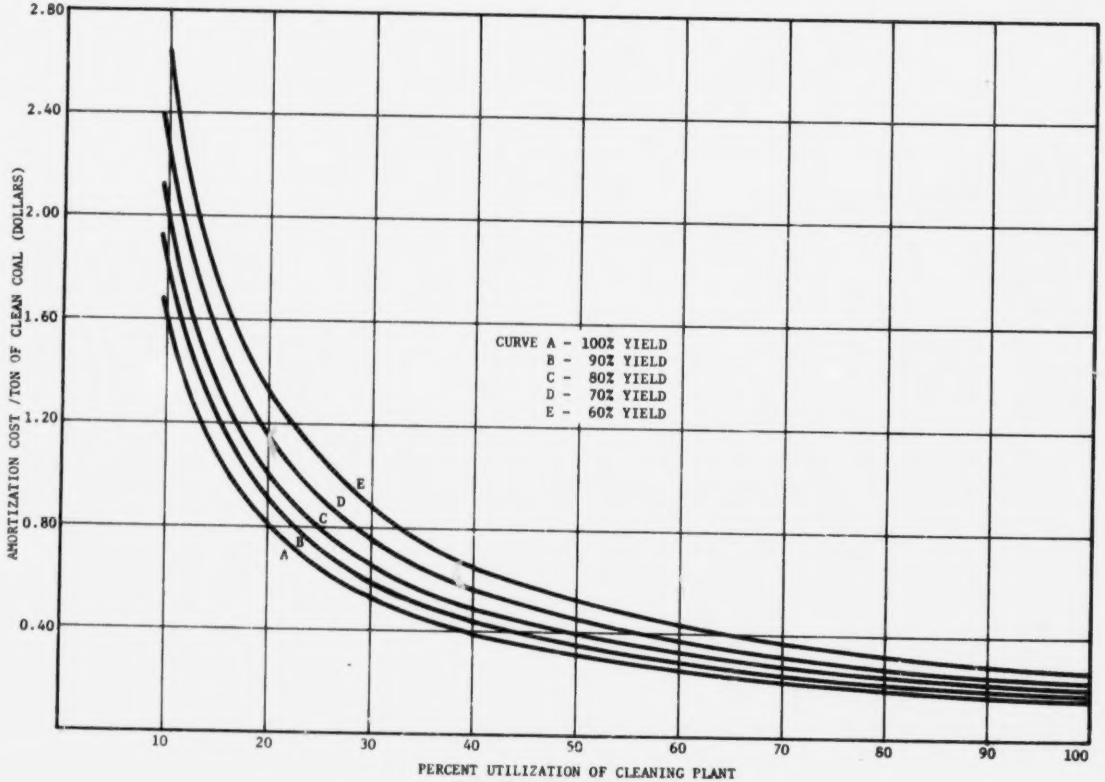

FIGURE IV-11
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $10,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 7% LOAN PERIOD - 10 YEARS

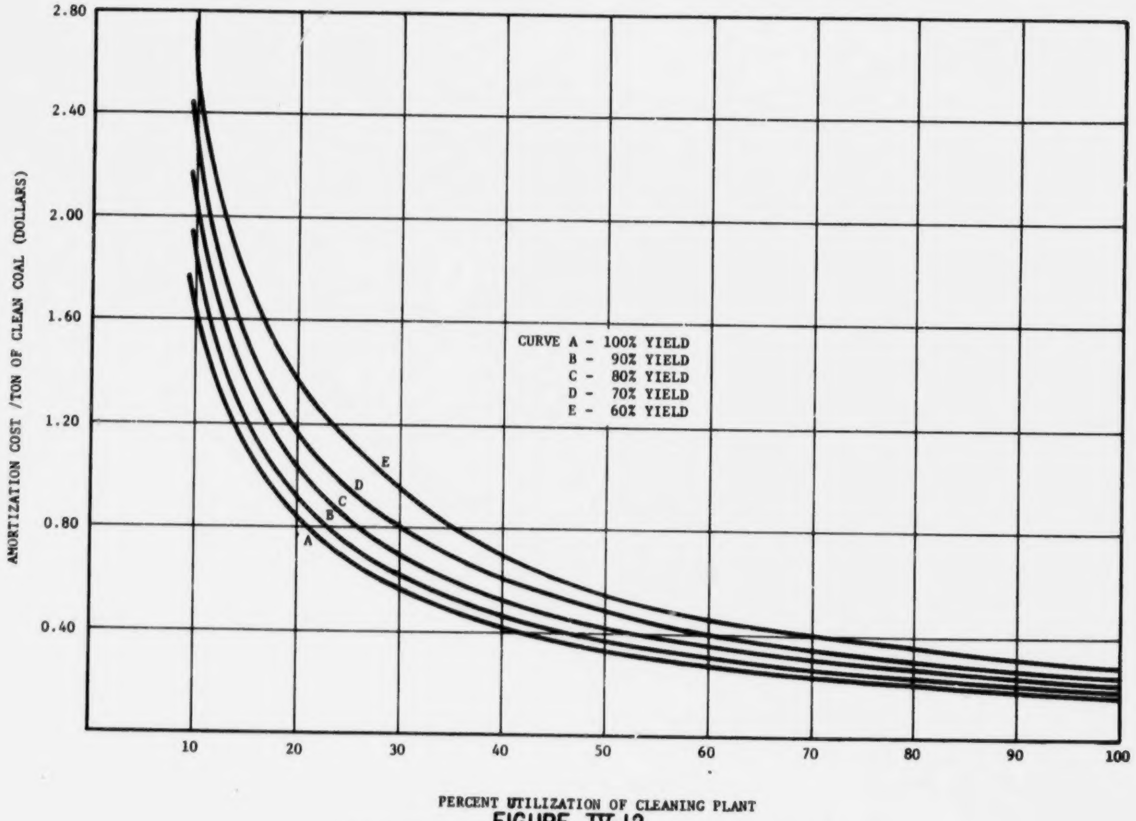

FIGURE IV-12
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $ 10,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8 % LOAN PERIOD-10 YEARS

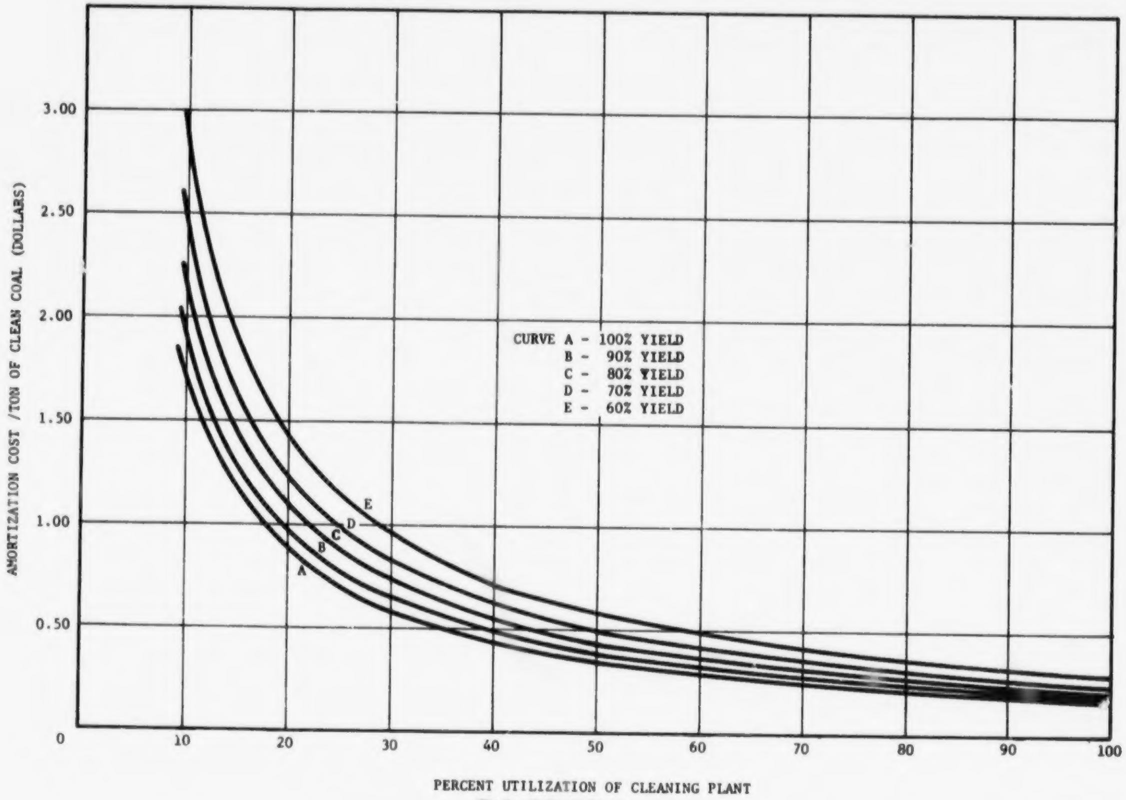

FIGURE IV-13

AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST -$ 10,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 9 % LOAN PERIOD -10 YEARS

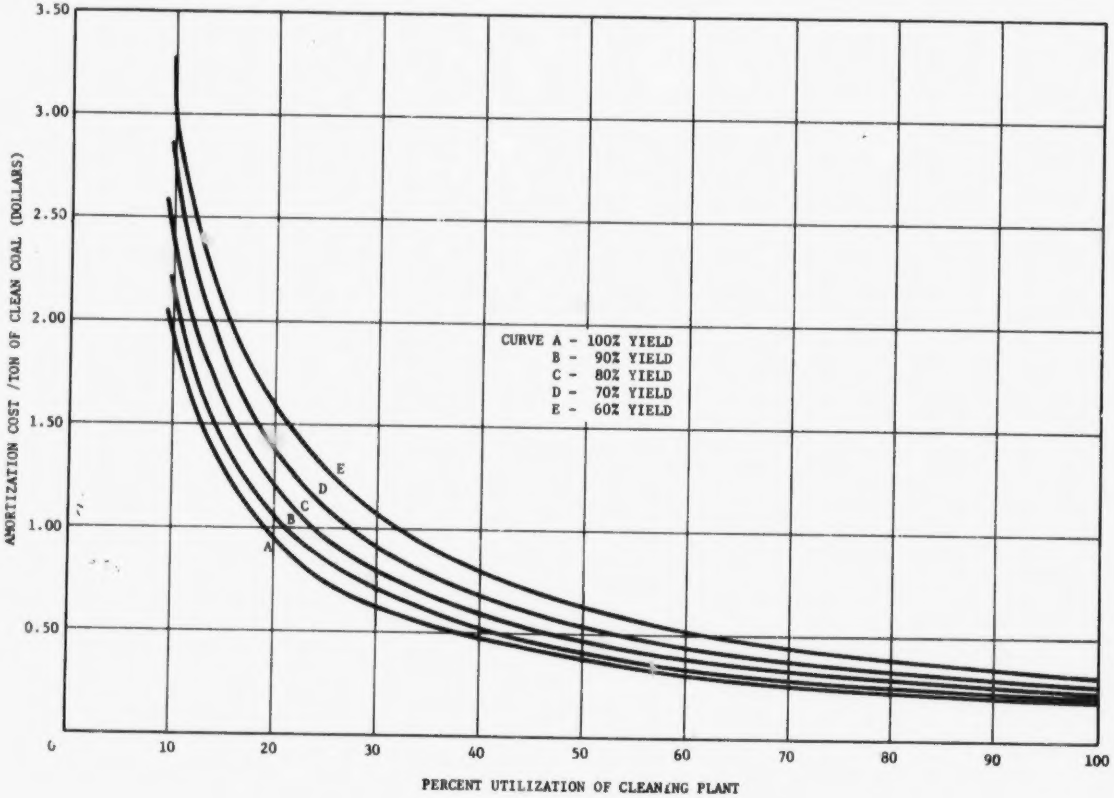

FIGURE IV-14

AMORTIZATION COST / TON CLEANED COAL

FOR:

PLANT COST - $12,000 PER TON HOUR INPUT CAPACITY

INTEREST RATE - 7 % LOAN PERIOD - 10 YEARS

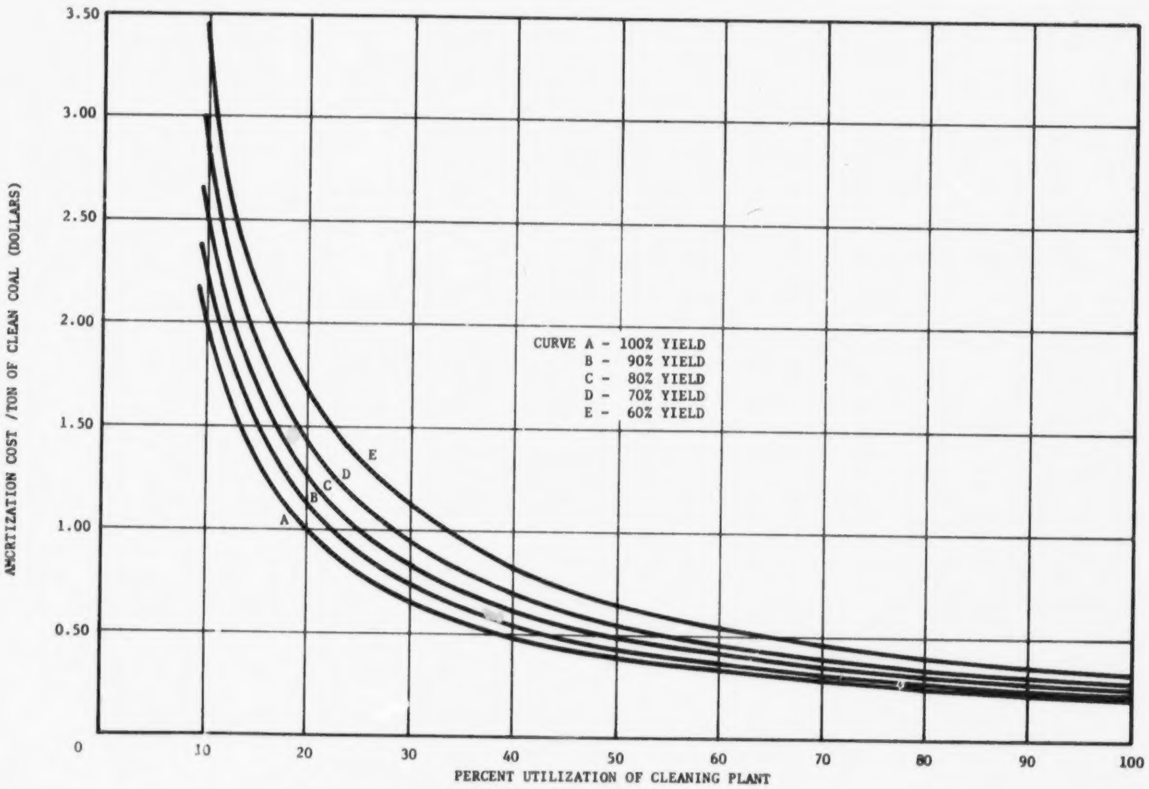

FIGURE IV-15
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $12,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8% LOAN PERIOD - 10 YEARS

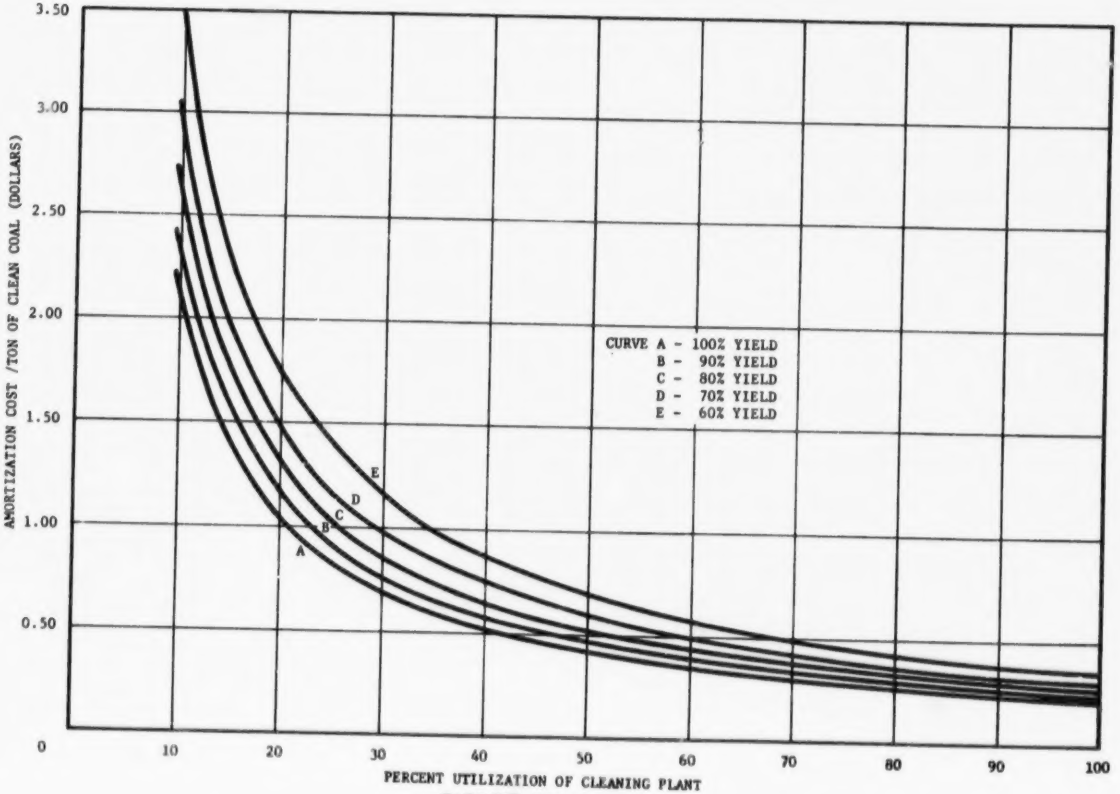

FIGURE IV-16

AMORTIZATION COST / TON CLEANED COAL

FOR:

PLANT COST -$12,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 9% LOAN PERIOD-10 YEARS

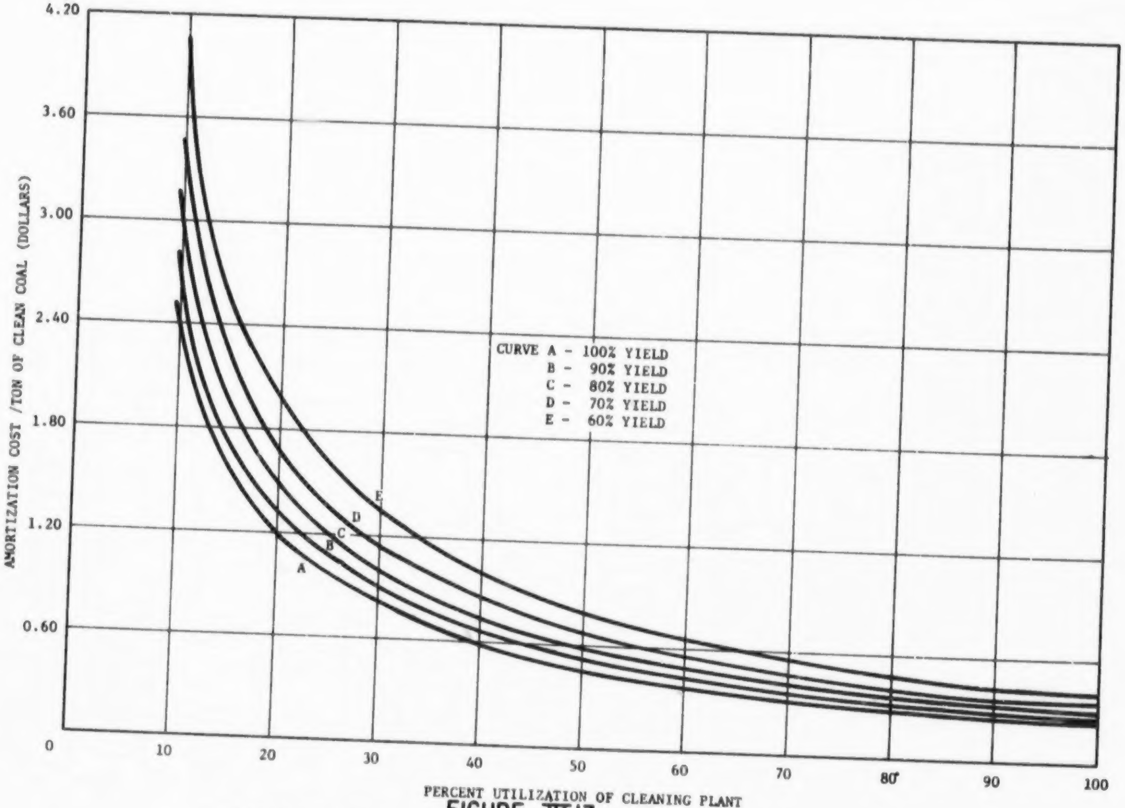

FIGURE IV-17
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST -$15,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 7% LOAN PERIOD - 10 YEARS

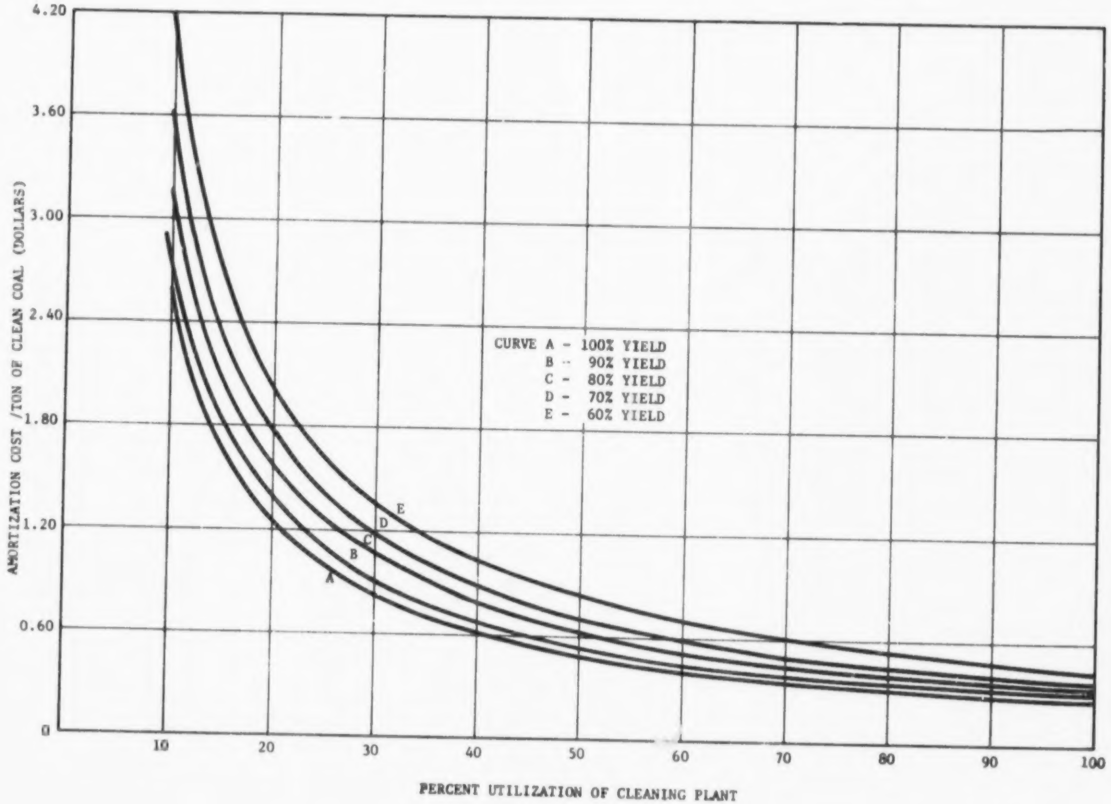

FIGURE IV-18
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST -$15,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 8% LOAN PERIOD - 10 YEARS

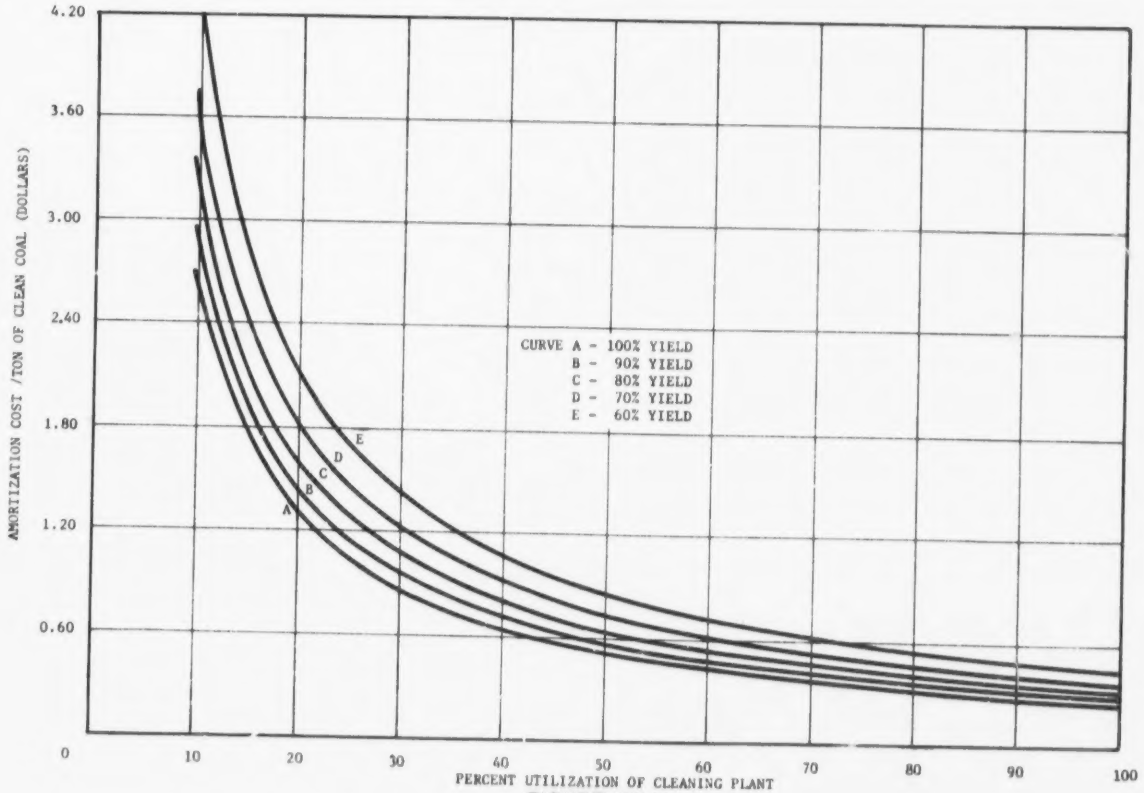

FIGURE IV-19
AMORTIZATION COST / TON CLEANED COAL
FOR:
PLANT COST - $ 15,000 PER TON HOUR INPUT CAPACITY
INTEREST RATE - 9 % LOAN PERIOD - 10 YEARS

APPENDIX V

OPERATION AND MAINTENANCE COST ESTIMATES

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APPENDIX V

OPERATION AND MAINTENANCE COST ESTIMATES

Information contained in the 1965 Paul Weir study was examined as a basis for developing current O & M cleaning plant costs attributable to a ton of cleaned coal. As indicated in the main body of this report, current anticipated O & M costs for various plant yields were derived from available 1965 data. The projections from the 1965 data follow. Figure V-I (also in main body of report) indicates the anticipated O & M costs for plants of the variety believed required to clean the more readily cleanable coals. The indicated maximum deviations (Δs) are the maximum anticipated O & M cost variations that may arise due to variations in plant characteristics and management concepts.

CASE I

MINE - ILLINOIS NO. 6 BED, FRANKLIN COUNTY
(Cost estimates based on available data)

Plant cost	$2,560,000
Plant capacity	700 t.p.h. raw coal feed
Date constructed	1960 (completed)
Plant type	Heavy media process for coarse coal, Deister tables for fine sizes, and thermal dryers
Original plant cost per ton hour input capacity . . .	$3,660
Projected current (1970) plant cost per ton hour input capacity.	$6,570

(Based on U.S. Bureau of Labor Statistics information on hourly wage rates for building contractors)

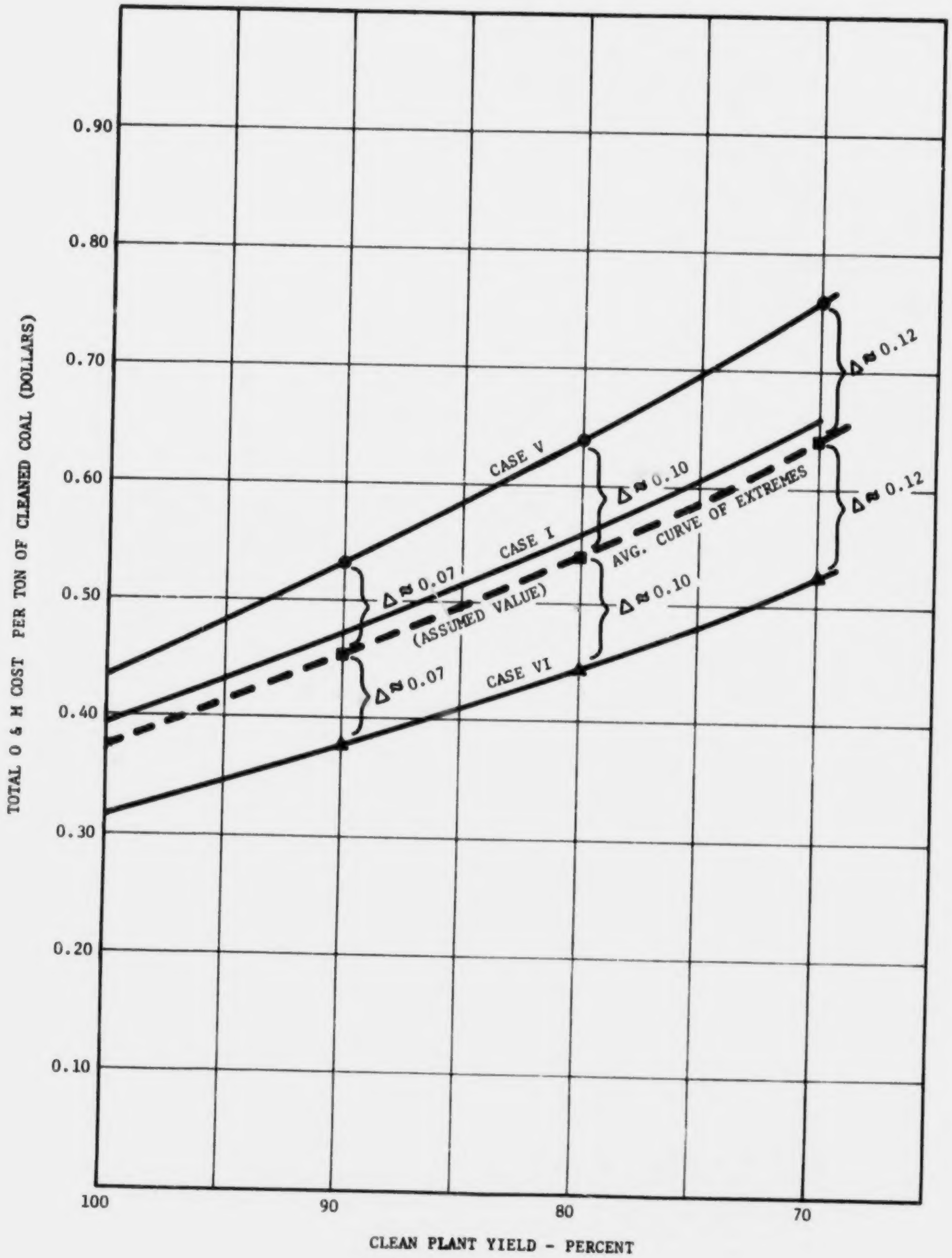

FIGURE V-1
OPERATION AND MAINTENANCE COST

1965 O & M Cost

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling)	$0.344/ton
Refuse handling	0.025/ton
Total	$0.369/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling) (=0.344 x .90/.80)	$0.387/ton
Refuse handling (=0.025 x 2)	0.050/ton
Total	$0.437/ton

- If coal is washed to produce 70% yield

Plant O & M cost (less refuse handling) (=0.344 x .90/.70)	$0.442/ton
Refuse handling (=0.025 x 3)	0,075/ton
Total	$0.517/ton

1970 O & M Cost

(Based on 1970 hourly earnings as compared to 1965 houly earnings. Source: U.S. Bureau of Labor Statistics)

- At 90% yield = 0.369 x 4.47/3.49 = $0.472/ton
- At 80% yield = 0.437 x 4.47/3.49 = $0.558/ton
- At 70% yield = 0.517 x 4.47/3.49 = $0.660/ton

CASE II

MINE - ILLINOIS NO. 6 BED, MONTGOMERY COUNTY
(Cost estimates based on available data)

Plant Cost	$2,200,000
Plant capacity	800 t.p.h. raw coal feed
Date constructed	Not known - older plant
Plant type	Uses a combination of wet washing and air tables for cleaning. Plant is not capable of cleaning coal at densities lower than 1.60.
Original plant cost per ton hour input capacity	$2,750

1965 O & M Cost

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling)	$0.2720
Refuse handling	0.0173
Total	$0.2893/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling)	$0.3060
Refuse handling	0.0346
Total	$0.3406

Due to equipment type, this plant is not capable of cleaning at lower densities and for the characteristics of coal processed, 80% yield appears to be cleaning limit.

1970 O & M Cost
(Based on 1970 hourly earnings as compared to 1965 hourly earnings. Source: U.S. Bureau of Labor Statistics)

- At 90% yield = 0.289 x 4.47/3.49 = $0.37/ton
- At 80% yield = 0.341 x 4.47/3.49 = $0.44/ton

CASE III

MINE - ILLINOIS NO. 5 BED, FULTON COUNTY
(Cost estimates based on available data)

Plant cost	. $2,700,000
Plant capacity	. 800 t.p.h. raw coal feed
Date constructed.	. Not known
Plant type	. Basically Baum jigs for cleaning. Contains two jigs for 6" x 0, one for 2" x 0, and a middling jig. The 1/4" x 0 is rewashed in a Rheolavour launder system. The 3/4" x 1/8" product is heat-dried.
Original plant cost per ton hour input capacity	. $3,380

1965 O & M Cost

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling) .	.$0.222/ton
Refuse handling	. 0.017/ton
Total	$0.239/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling) .	.$0.250/ton
Refuse handling	. 0.033/ton
Total	$0.283/ton

- If coal is washed to produce 70% yield

Plant O & M cost (less refuse handling) .	.$0.286/ton
Refuse handling	. 0.050/ton
Total	$0.336/ton

1970 O & M Cost

(Based on 1970 hourly earnings as compared to 1965 hourly earnings. Source: U.S. Bureau of Labor Statistics)

- At 90% yield = 0.239 x 4.47/3.49 = $0.306/ton
- At 80% yield = 0.283 x 4.47/3.49 = $0.352/ton
- At 70% yield = 0.336 x 4.47/3.49 = $0.42/ton

CASE IV

MINE - WEST KENTUCKY NO. 9 BED, UNION COUNTY

(Cost estimates based on available data)

Plant cost	. $1,850,000
Plant capacity	. 1,000 t.p.h. raw coal feed
Date constructed.	. Not known
Plant type	. Basically consists of two parallel Baum type jigs, and a smaller piston type jig for cleaning 28 mesh x 0. No heat dryers.
Original plant cost per ton hour input capacity	. $1,850

1965 O & M Cost

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling) . .	. $0.152/ton
Refuse handling.	. 0.033/ton
Total	$0.185/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling)	$0.170/ton
Refuse handling	0.067/ton
Total	$0.237/ton

- If coal is washed to produce 70% yield

Plant O & M cost (less refuse handling)	$0.195/ton
Refuse handling	0.100/ton
Total	$0.295/ton

1970 O & M Cost

(Based on 1970 hourly earnings as compared to 1965 hourly earnings. Source: U.S. Bureau of Labor Statistics)

- At 90% yield = $0.237/ton

- At 80% yield = $0.304/ton

- At 70% yield = $0.378/ton

CASE V

MINE - PITTSBURGH BED, GREENE COUNTY, PA.
(Cost estimates based on available data)

Plant cost	$3,500,000
Plant capacity	500 t.p.h. raw coal feed
Date constructed	Completed 1964 or 1965
Plant type	Employs separator screens, sink and float screens, flotation cells, Deister tables, magnetite separators, and heat dryers.
Original plant cost per ton hour input capacity	$7,000
Projected current (1970) plant cost per ton hour input capacity	$10,000 to $11,300

(Based on U.S. Bureau of Labor Statistics information on hourly wage rates for building contractors.)

1965 O & M Costs

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling)	$0.380/ton
Refuse handling	0.035/ton
Total	$0.415/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling)	$0.428/ton
Refuse handling	0.070/ton
Total	$0.498/ton

- If coal is washed to produce 70% yield

Plant O & M cost (less refuse handling). .	$0.488/ton
Refuse handling	0.105/ton
	$0.593/ton

1970 O & M Cost

(Based on 1970 hourly earnings as compared to 1965 hourly earnings. Source: U. S. Bureau of Labor Statistics)

- At 90% yield = $0.532/ton

- At 80% yield = $0.638/ton

- At 70% yield = $0.76/ton

CASE VI

MINE - OHIO NO. 8 BED, HARRISON AND BELMONT COUNTIES
(Cost estimates based on available data)

Plant cost	$7,500,000
Plant capacity	1500 t.p.h. raw coal feed
Date constructed	Not known
Plant type	Essentially consists of Baum type jigs, chance dense media cones, Deister tables, and heat dryers.
Original plant cost per ton hour input capacity	$5,000

1965 O & M Cost

- If coal is washed to produce 90% yield

Plant O & M cost (less refuse handling). .	$0.277/ton
Refuse handling	0.018/ton
Total	$0.295/ton

- If coal is washed to produce 80% yield

Plant O & M cost (less refuse handling) . .	$0.311/ton
Refuse handling.	0.036/ton
Total	$0.347/ton

- If coal is washed to produce 70% yield

Plant O & M cost (less refuse handling) . .	$0.355/ton
Refuse handling.	0.054/ton
Total	$0.409/ton

1970 O & M Cost

(Based on 1970 hourly earnings as compared to 1965 hourly earnings. Source: U.S. Bureau of Labor Statistics)

- At 90% yield = $0.377/ton

- At 80% yield = $0.444/ton

- At 70% yield = $0.523/ton

APPENDIX VI

COST/BENEFIT ANALYSIS CASE STUDIES

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APPENDIX VI

COST/BENEFIT ANALYSIS CASE STUDIES

This appendix analyzes the cost/benefit factors associated with thirty potential clean coal source/destination cases. These detailed analyses support the summary presentations in Section 7.0.

CASE # 1A

1.0 CASE CONDITIONS

1.1 Mine Location ALLEGANY COUNTY, MARYLAND

1.2 Consumer Location BALTIMORE, MARYLAND

1.3 Raw Coal: 20.3 % Ash 1.13 % Total Sulfur

1.4 Cleaned Coal: 13.1 % Ash 1.06 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,200 BTUs/pound

1.6 Cleaning Plant Yield = 81 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.93 /ton

$5.00/ton, additional cost is . . . . . .$ 1.18 /ton

$6.00/ton, additional cost is . . . . . .$ 1.41 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 1A Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.95 /ton

$5.00/ton, differential cost is . . . .$ 2.20 /ton

$6.00/ton, differential cost is . . . .$ 2.43 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.34 /ton

$6.00/ton, benefit is . . . .$ 0.40 /ton

$7.00/ton, benefit is . . . .$ 0.47 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.35 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.09 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 1A Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$1.03 /ton

$6.00/ton, benefit is . . . .$1.09 /ton

$7.00/ton, benefit is . . . .$1.16 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.77 /ton

$6.00/ton, benefit is . . . .$ 0.83 /ton

$7.00/ton, benefit is . . . .$ 0.90 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.92	0.86	0.79
$5.00	---	1.11	1.04
$6.00	---	---	1.27

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.18	1.12	1.05
$5.00	---	1.37	1.30
$6.00	---	---	1.53

CASE # 1B

1.0 CASE CONDITIONS

1.1 Mine Location ALLEGANY COUNTY, MARYLAND

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 20.3 % Ash 1.13 % Total Sulfur

1.4 Cleaned Coal: 13.1 % Ash 1.06 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,200 BTUs/pound

1.6 Cleaning Plant Yield = 81 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.93 /ton

$5.00/ton, additional cost is . . . . . .$ 1.18 /ton

$6.00/ton, additional cost is . . . . . .$ 1.41 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 1B Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.95 /ton

$5.00/ton, differential cost is . . . .$ 2.20 /ton

$6.00/ton, differential cost is . . . .$ 2.43 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.34 /ton

$6.00/ton, benefit is . . . .$ 0.40 /ton

$7.00/ton, benefit is . . . .$ 0.47 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.35 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.08 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 1B Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.03 /ton

$6.00/ton, benefit is . . . .$ 1.09 /ton

$7.00/ton, benefit is . . . .$ 1.16 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.76 /ton

$6.00/ton, benefit is . . . .$ 0.82 /ton

$7.00/ton, benefit is . . . .$ 0.89 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.92	0.86	0.79
$5.00	---	1.11	1.04
$6.00	---	---	1.27

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.19	1.13	1.06
$5.00	---	1.38	1.31
$6.00	---	---	1.54

CASE # 2

1.0 CASE CONDITIONS

1.1 Mine Location GARRETT COUNTY, MARYLAND

1.2 Consumer Location BALTIMORE, MARYLAND

1.3 Raw Coal: 12.0 % Ash 0.96 % Total Sulfur

1.4 Cleaned Coal: 8.0 % Ash 0.64 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,000 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.45 /ton

$5.00/ton, additional cost is . . . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 2 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.33 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.19 /ton

$6.00/ton, benefit is . . . .$ 0.23 /ton

$7.00/ton, benefit is . . . .$ 0.27 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.20 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.07 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.08 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 2 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.60 /ton

$6.00/ton, benefit is . . . .$ 0.64 /ton

$7.00/ton, benefit is . . . .$ 0.68 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.47 /ton

$6.00/ton, benefit is . . . .$ 0.51 /ton

$7.00/ton, benefit is . . . .$ 0.55 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	0.73	0.69	0.65
$5.00	---	0.79	0.75
$6.00	---	---	0.87

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	0.86	0.82	0.78
$5.00	---	0.92	0.88
$6.00	---	---	1.00

CASE # 3

1.0 CASE CONDITIONS

1.1 Mine Location GARRETT COUNTY, MARYLAND

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 14.4 % Ash 1.14 % Total Sulfur

1.4 Cleaned Coal: 9.6 % Ash 0.82 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,700 BTUs/pound

1.6 Cleaning Plant Yield = 89 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.39 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.46 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.50 /ton

$5.00/ton, additional cost is . . . . . .$ 0.62 /ton

$6.00/ton, additional cost is . . . . . .$ 0.74 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 3 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.40 /ton

$5.00/ton, differential cost is . . . .$ 1.52 /ton

$6.00/ton, differential cost is . . . .$ 1.64 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.23 /ton

$6.00/ton, benefit is . . . .$ 0.28 /ton

$7.00/ton, benefit is . . . .$ 0.32 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.24 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.07 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.10 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.12 /ton

Case 3 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.72 /ton

$6.00/ton, benefit is . . . .$ 0.77 /ton

$7.00/ton, benefit is . . . .$ 0.81 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.55 /ton

$6.00/ton, benefit is . . . .$ 0.60 /ton

$7.00/ton, benefit is . . . .$ 0.64 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.68	0.63	0.59
$5.00	---	0.75	0.71
$6.00	---	---	0.83

6.2 For unit train shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.85	0.80	0.76
$5.00	---	0.92	0.88
$6.00	---	---	1.00

CASE # 4

1.0 CASE CONDITIONS

1.1 Mine Location ALLEGANY COUNTY, MARYLAND

1.2 Consumer Location BALTIMORE, MARYLAND

1.3 Raw Coal: 11.9 % Ash 1.13 % Total Sulfur

1.4 Cleaned Coal: 10.6 % Ash 1.07 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,600 BTUs/pound

1.6 Cleaning Plant Yield = 97 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.36 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.40 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.13/ton

$5.00/ton, additional cost is . . . .$ 0.15/ton

$6.00/ton, additional cost is . . . .$ 0.19/ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . . .$ 0.05/ton

Case 4 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 0.94 /ton

$5.00/ton, differential cost is . . . .$ 0.96 /ton

$6.00/ton, differential cost is . . . .$ 1.00 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.06 /ton

$6.00/ton, benefit is . . . .$ 0.08 /ton

$7.00/ton, benefit is . . . .$ 0.09 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.07 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.02 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.03 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ -0- /ton

4.5 Saving in benefit payment (Figure 6-8). . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.05 /ton

Case 4 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$0.22 /ton

$6.00/ton, benefit is . . . .$0.24 /ton

$7.00/ton, benefit is . . . .$0.25 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.17 /ton

$6.00/ton, benefit is . . . .$ 0.19 /ton

$7.00/ton, benefit is . . . .$ 0.20 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.72	0.70	0.69
$5.00	---	0.72	0.71
$6.00	---	---	0.75

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.77	0.75	0.74
$5.00	---	0.77	0.76
$6.00	---	---	0.80

CASE # 5

1.0 CASE CONDITIONS

1.1 Mine Location COLUMBIANA COUNTY, OHIO

1.2 Consumer Location CLEVELAND, OHIO

1.3 Raw Coal: 10.39% Ash 2.34 % Total Sulfur

1.4 Cleaned Coal: 4.68% Ash 0.62 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,400 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.44 /ton

$5.00/ton, additional cost is . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 5 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.32 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.27 /ton

$6.00/ton, benefit is . . . .$ 0.32 /ton

$7.00/ton, benefit is . . . .$ 0.38 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.21 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.05 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.12 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 5 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . . $0.77 /ton

$6.00/ton, benefit is . . . . $0.82 /ton

$7.00/ton, benefit is . . . . $0.88 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . . $ 0.61 /ton

$6.00/ton, benefit is . . . . $ 0.66 /ton

$7.00/ton, benefit is . . . . $ 0.72 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.55	0.50	0.44
$5.00	---	0.61	0.55
$6.00	---	---	0.67

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.71	0.66	0.60
$5.00	---	0.77	0.71
$6.00	---	---	0.83

CASE # 6

1.0 CASE CONDITIONS

1.1 Mine Location COLUMBIANA COUNTY, OHIO

1.2 Consumer Location YOUNGSTOWN, OHIO

1.3 Raw Coal: 9.32 % Ash 2.39 % Total Sulfur

1.4 Cleaned Coal: 3.90 % Ash 0.99 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,400 BTUs/pound

1.6 Cleaning Plant Yield = 85 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.40 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.50 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.70 /ton

$5.00/ton, additional cost is . . . . . .$ 0.88 /ton

$6.00/ton, additional cost is . . . . . .$ 1.07 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 6 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.66 /ton

$5.00/ton, differential cost is . . . .$ 1.84 /ton

$6.00/ton, differential cost is . . . .$ 2.03 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.26 /ton

$6.00/ton, benefit is . . . .$ 0.31 /ton

$7.00/ton, benefit is . . . .$ 0.36 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on truck shipment . . . .$ 0.06 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.11 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.12 /ton

Case 6 Continued

5.0 TOTAL BENEFITS ASSESSMENT

Total benefits with truck shipment rate when F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.58 /ton

$6.00/ton, benefit is . . . .$ 0.63 /ton

$7.00/ton, benefit is . . . .$ 0.68 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

For truck shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.08	1.03	0.98
$5.00	---	1.21	1.16
$6.00	---	---	1.35

CASE # 7

1.0 CASE CONDITIONS

1.1 Mine Location HARRISON COUNTY, OHIO

1.2 Consumer Location DETROIT, MICHIGAN

1.3 Raw Coal: 10.44 % Ash 2.30 % Total Sulfur

1.4 Cleaned Coal: 4.07 % Ash 1.09 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,400 BTUs/pound

1.6 Cleaning Plant Yield = 85 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.40 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.50 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.70 /ton

$5.00/ton, additional cost is . . . . . .$ 0.88 /ton

$6.00/ton, additional cost is . . . . . .$ 1.07 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 7 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.66 /ton

$5.00/ton, differential cost is . . . .$ 1.84 /ton

$6.00/ton, differential cost is . . . .$ 2.03 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.30 /ton

$6.00/ton, benefit is . . . .$ 0.36 /ton

$7.00/ton, benefit is . . . .$ 0.42 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.29 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.13 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.14 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 7 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.91 /ton

$6.00/ton, benefit is . . . .$ 0.97 /ton

$7.00/ton, benefit is . . . .$ 1.03 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.75 /ton

$6.00/ton, benefit is . . . .$ 0.81 /ton

$7.00/ton, benefit is . . . .$ 0.87 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.75	0.69	0.63
$5.00	---	0.87	0.81
$6.00	---	---	1.00

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.91	0.85	0.81
$5.00	---	1.03	0.97
$6.00	---	---	1.16

CASE # 8

1.0 CASE CONDITIONS

1.1 Mine Location MAHONING COUNTY, OHIO

1.2 Consumer Location YOUNGSTOWN, OHIO

1.3 Raw Coal: 7.64 % Ash 2.67 % Total Sulfur

1.4 Cleaned Coal: 3.19 % Ash 1.04 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.6 Cleaning Plant Yield = 86 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.40 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.49 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.65 /ton

$5.00/ton, additional cost is . . . . . .$ 0.82 /ton

$6.00/ton, additional cost is . . . . . .$ 0.98 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 8 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$1.60 /ton

$5.00/ton, differential cost is . . . .$1.77 /ton

$6.00/ton, differential cost is . . . .$1.93 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$0.21 /ton

$6.00/ton, benefit is . . . .$0.26 /ton

$7.00/ton, benefit is . . . .$0.30 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on truck shipment . . . .$0.05 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$0.09 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$0.12 /ton

Case 8 Continued

5.0 TOTAL BENEFITS ASSESSMENT

Total benefits with truck shipment rate when F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.50 /ton

$6.00/ton, benefit is . . . .$ 0.55 /ton

$7.00/ton, benefit is . . . .$ 0.59 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

For truck shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.10	1.05	1.01
$5.00	---	1.22	1.18
$6.00	---	---	1.34

CASE # 9

1.0 CASE CONDITIONS

1.1 Mine Location ARMSTRONG COUNTY, PENNSYLVANIA

1.2 Consumer Location INDIANA, PENNSYLVANIA

1.3 Raw Coal: 12.99 % Ash 2.53 % Total Sulfur

1.4 Cleaned Coal: 6.10 % Ash 1.02 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,200 BTUs/pound

1.6 Cleaning Plant Yield = 87 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.40 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.48 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.60 /ton

$5.00/ton, additional cost is . . . . . .$ 0.75 /ton

$6.00/ton, additional cost is . . . . . .$ 0.90 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 9 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$1.53 /ton

$5.00/ton, differential cost is . . . .$1.68 /ton

$6.00/ton, differential cost is . . . .$1.83 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$0.32 /ton

$6.00/ton, benefit is . . . .$0.39 /ton

$7.00/ton, benefit is . . . .$0.45 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on truck shipment . . . .$0.08 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$0.14 /ton

5.0 TOTAL BENEFITS ASSESSMENT

Total benefits with truck shipment rate when F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.74 /ton

$6.00/ton, benefit is . . . .$ 0.81 /ton

$7.00/ton, benefit is . . . .$ 0.87 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

For truck shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.79	0.72	0.66
$5.00	---	0.87	0.81
$6.00	---	---	0.96

CASE # 10

1.0 CASE CONDITIONS

1.1 Mine Location ARMSTRONG COUNTY, PENNSYLVANIA

1.2 Consumer Location (MINE MOUTH)

1.3 Raw Coal: 21.55 % Ash 2.22 % Total Sulfur

1.4 Cleaned Coal: 7.86 % Ash 0.99 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,900 BTUs/pound

1.6 Cleaning Plant Yield = 78 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.44 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.55 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 1.13 /ton

$5.00/ton, additional cost is . . . .$ 1.41 /ton

$6.00/ton, additional cost is . . . .$ 1.70 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 10 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.18 /ton

$5.00/ton, differential cost is . . . .$ 2.46 /ton

$6.00/ton, differential cost is . . . .$ 2.75 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.60 /ton

$6.00/ton, benefit is . . . .$ 0.72 /ton

$7.00/ton, benefit is . . . .$ 0.84 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

No Shipping . . . .$ -0- /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.31 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.03 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.05 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.18 /ton

Case 10 Continued

5.0 TOTAL BENEFITS ASSESSMENT

Total benefits with truck shipment rate when F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.17 /ton

$6.00/ton, benefit is . . . .$ 1.29 /ton

$7.00/ton, benefit is . . . .$ 1.41 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

(No Shipping)

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.01	0.89	0.77
$5.00	---	1.17	1.05
$6.00	---	---	1.43

CASE # 11

1.0 CASE CONDITIONS

1.1 Mine Location BUTLER COUNTY, PENNSYLVANIA

1.2 Consumer Location ASTABULA, OHIO

1.3 Raw Coal: 19.4 % Ash 1.32 % Total Sulfur

1.4 Cleaned Coal: 8.7 % Ash 0.98 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,800 BTUs/pound

1.6 Cleaning Plant Yield = 80 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.54 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 1.00 /ton

$5.00/ton, additional cost is . . . . . .$ 1.25 /ton

$6.00/ton, additional cost is . . . . . .$ 1.50 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 11 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.03 /ton

$5.00/ton, differential cost is . . . .$ 2.28 /ton

$6.00/ton, differential cost is . . . .$ 2.53 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.48 /ton

$6.00/ton, benefit is . . . .$ 0.58 /ton

$7.00/ton, benefit is . . . .$ 0.68 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.32 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.08 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.24 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.04 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.16 /ton

Case 11 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.26 /ton

$6.00/ton, benefit is . . . .$ 1.36 /ton

$7.00/ton, benefit is . . . .$ 1.46 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.02 /ton

$6.00/ton, benefit is . . . .$ 1.12 /ton

$7.00/ton, benefit is . . . .$ 1.22 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.77	0.67	0.57
$5.00	---	0.92	0.82
$6.00	---	---	1.07

6.2 For unit train shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.01	0.91	0.81
$5.00	---	1.16	1.06
$6.00	---	---	1.31

CASE # 12

1.0 CASE CONDITIONS

1.1 Mine Location ALLEGHANY COUNTY, PENNSYLVANIA

1.2 Consumer Location PITTSBURGH, PENNSYLVANIA

1.3 Raw Coal: 22.70 % Ash 1.97 % Total Sulfur

1.4 Cleaned Coal: 8.55 % Ash 1.00 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,300 BTUs/pound

1.6 Cleaning Plant Yield = 76 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.45 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.58 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 1.27 /ton

$5.00/ton, additional cost is . . . .$ 1.58 /ton

$6.00/ton, additional cost is . . . .$ 1.89 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 12 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.36 /ton

$5.00/ton, differential cost is . . . .$ 2.67 /ton

$6.00/ton, differential cost is . . . .$ 2.98 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.62 /ton

$6.00/ton, benefit is . . . .$ 0.74 /ton

$7.00/ton, benefit is . . . .$ 0.87 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on truck shipment . . . .$ 0.12 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.32 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.03 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.05 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.20 /ton

Case 12 Continued

5.0 TOTAL BENEFITS ASSESSMENT

Total benefits with truck shipment rate when F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.02 /ton

$6.00/ton, benefit is . . . .$ 0.90 /ton

$7.00/ton, benefit is . . . .$ 0.77 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

For truck shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.02	0.90	0.77
$5.00	---	1.21	1.08
$6.00	---	---	1.39

CASE # 13

1.0 CASE CONDITIONS

1.1 Mine Location LAWRENCE COUNTY, PENNSYLVANIA

1.2 Consumer Location PITTSBURGH, PENNSYLVANIA

1.3 Raw Coal: 4.7 % Ash 2.35 % Total Sulfur

1.4 Cleaned Coal: 2.5 % Ash 1.03 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,000 BTUs/pound

1.6 Cleaning Plant Yield = 95 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.36 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.41 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.22 /ton

$5.00/ton, additional cost is . . . .$ 0.27 /ton

$6.00/ton, additional cost is . . . .$ 0.32 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . . .$ 0.05 /ton

Case 13 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.04 /ton

$5.00/ton, differential cost is . . . .$ 1.09 /ton

$6.00/ton, differential cost is . . . .$ 1.14 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.11 /ton

$6.00/ton, benefit is . . . .$ 0.13 /ton

$7.00/ton, benefit is . . . .$ 0.15 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.05 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.01 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.05 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 13 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.33 /ton

$6.00/ton, benefit is . . . .$ 0.35 /ton

$7.00/ton, benefit is . . . .$ 0.37 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.29 /ton

$6.00/ton, benefit is . . . .$ 0.31 /ton

$7.00/ton, benefit is . . . .$ 0.33 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.71	0.69	0.67
$5.00	---	0.74	0.72
$6.00	---	---	0.77

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.75	0.73	0.71
$5.00	---	0.78	0.76
$6.00	---	---	0.81

CASE # 14

1.0 CASE CONDITIONS

1.1 Mine Location CAMBRIA COUNTY, PENNSYLVANIA

1.2 Consumer Location BOSTON, MASSACHUSETTS

1.3 Raw Coal: 15.95% Ash 2.57 % Total Sulfur

1.4 Cleaned Coal: 4.92% Ash 1.03 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 13,200 BTUs/pound

1.6 Cleaning Plant Yield = 82 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.42 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.52 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.88 /ton

$5.00/ton, additional cost is . . . . . .$ 1.10 /ton

$6.00/ton, additional cost is . . . . . .$ 1.32 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 14 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.88 /ton

$5.00/ton, differential cost is . . . .$ 2.10 /ton

$6.00/ton, differential cost is . . . .$ 2.32 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.50 /ton

$6.00/ton, benefit is . . . .$ 0.60 /ton

$7.00/ton, benefit is . . . .$ 0.70 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.66 /ton

Saving on unit train shipment @ 0.80c/ton mile . . . .$ 0.42 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.24 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.04 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.18 /ton

Case 14 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.64 /ton

$6.00/ton, benefit is . . . .$ 1.74 /ton

$7.00/ton, benefit is . . . .$ 1.84 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.40 /ton

$6.00/ton, benefit is . . . .$ 1.50 /ton

$7.00/ton, benefit is . . . .$ 1.60 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.24	0.14	0.04
$5.00	---	0.36	0.26
$6.00	---	---	0.48

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.48	0.38	0.28
$5.00	---	0.60	0.50
$6.00	---	---	0.72

CASE # 15

1.0 CASE CONDITIONS

1.1 Mine Location SUMMERSET COUNTY, PENNSYLVANIA

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 15.95% Ash 2.58 % Total Sulfur

1.4 Cleaned Coal: 7.10% Ash 0.72 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.6 Cleaning Plant Yield = 87 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.40 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.48 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.60 /ton

$5.00/ton, additional cost is . . . .$ 0.75 /ton

$6.00/ton, additional cost is . . . .$ 0.90 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 15 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.53 /ton

$5.00/ton, differential cost is . . . .$ 1.68 /ton

$6.00/ton, differential cost is . . . .$ 1.83 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.41 /ton

$6.00/ton, benefit is . . . .$ 0.49 /ton

$7.00/ton, benefit is . . . .$ 0.57 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.42 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.12 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.19 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.16 /ton

Case 15 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.23 /ton

$6.00/ton, benefit is . . . .$ 1.31 /ton

$7.00/ton, benefit is . . . .$ 1.39 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.93 /ton

$6.00/ton, benefit is . . . .$ 1.01 /ton

$7.00/ton, benefit is . . . .$ 1.09 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.30	0.22	0.14
$5.00	---	0.37	0.29
$6.00	---	---	0.44

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.60	0.52	0.44
$5.00	---	0.67	0.59
$6.00	---	---	0.74

CASE # 16

1.0 CASE CONDITIONS

1.1 Mine Location CLEARFIELD COUNTY, PENNSYLVANIA

1.2 Consumer Location NEWARK, NEW JERSEY

1.3 Raw Coal: 11.60 % Ash 2.57 % Total Sulfur

1.4 Cleaned Coal: 4.66 % Ash 1.01 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,800 BTUs/pound

1.6 Cleaning Plant Yield = 81 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.94 /ton

$5.00/ton, additional cost is . . . . . .$ 1.17 /ton

$6.00/ton, additional cost is . . . . . .$ 1.40 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 16 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.96 /ton

$5.00/ton, differential cost is . . . .$ 2.19 /ton

$6.00/ton, differential cost is . . . .$ 2.42 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.33 /ton

$6.00/ton, benefit is . . . .$ 0.39 /ton

$7.00/ton, benefit is . . . .$ 0.46 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.36 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.21 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 16 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.03 /ton

$6.00/ton, benefit is . . . .$ 1.09 /ton

$7.00/ton, benefit is . . . .$ 1.16 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.88 /ton

$6.00/ton, benefit is . . . .$ 0.94 /ton

$7.00/ton, benefit is . . . .$ 1.01 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.93	0.87	0.80
$5.00	---	1.10	1.03
$6.00	---	---	1.26

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.08	1.02	0.95
$5.00	---	1.25	1.18
$6.00	---	---	1.41

CASE # 17

1.0 CASE CONDITIONS

1.1 Mine Location JEFFERSON COUNTY, PENNSYLVANIA

1.2 Consumer Location DETROIT, MICHIGAN

1.3 Raw Coal: 8.4 % Ash 1.33 % Total Sulfur

1.4 Cleaned Coal: 6.8 % Ash 1.08 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.6 Cleaning Plant Yield = 96 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.36 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.40 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.17 /ton

$5.00/ton, additional cost is . . . .$ 0.21 /ton

$6.00/ton, additional cost is . . . .$ 0.25 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . . .$ 0.05 /ton

Case 17 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 0.98 /ton

$5.00/ton, differential cost is . . . .$ 1.02 /ton

$6.00/ton, differential cost is . . . .$ 1.06 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.08 /ton

$6.00/ton, benefit is . . . .$ 0.09 /ton

$7.00/ton, benefit is . . . .$ 0.11 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.09 /ton

Saving on unit train shipment @ 0.80c/ton mile . . . .$ 0.05 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.03 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . . .$ -0- /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.05 /ton

Case 17 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.26 /ton

$6.00/ton, benefit is . . . .$ 0.27 /ton

$7.00/ton, benefit is . . . .$ 0.29 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.22 /ton

$6.00/ton, benefit is . . . .$ 0.23 /ton

$7.00/ton, benefit is . . . .$ 0.25 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.72	0.71	0.69
$5.00	---	0.75	0.73
$6.00	---	---	0.77

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.76	0.75	0.73
$5.00	---	0.79	0.77
$6.00	---	---	0.81

CASE # 18A

1.0 CASE CONDITIONS

1.1 Mine Location PRESTON COUNTY, WEST VIRGINIA

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 35.26% Ash 2.36 % Total Sulfur

1.4 Cleaned Coal: 11.65% Ash 1.31 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,900 BTUs/pound

1.6 Cleaning Plant Yield = 61 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.57 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.73 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 2.55 /ton

$5.00/ton, additional cost is . . . . . .$ 3.20 /ton

$6.00/ton, additional cost is . . . . . .$ 3.84 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.08 /ton

Case 18A Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When [illegible] ue of raw coal is -

$4 [illegible] /ton, differential cost is . . . .$ 3.93 /ton

$5.00/ton, differential cost is . . . .$ 4.58 /ton

$6.00/ton, differential cost is . . . .$ 5.22 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.96 /ton

$6.00/ton, benefit is . . . .$ 1.15 /ton

$7.00/ton, benefit is . . . .$ 1.34 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.99 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.34 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.58 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.05 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.08 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.20 /ton

Case 18A Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 2.86 /ton

$6.00/ton, benefit is . . . .$ 3.05 /ton

$7.00/ton, benefit is . . . .$ 3.24 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 2.21 /ton

$6.00/ton, benefit is . . . .$ 2.40 /ton

$7.00/ton, benefit is . . . .$ 2.59 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.07	0.88	0.69
$5.00	---	1.53	1.34
$6.00	---	---	1.98

6.2 For unit train shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.72	1.53	1.34
$5.00	---	2.18	1.99
$6.00	---	---	2.63

CASE # 18B

1.0 CASE CONDITIONS

1.1 Mine Location PRESTON COUNTY, WEST VIRGINIA

1.2 Consumer Location NEWARK, NEW JERSEY

1.3 Raw Coal: 35.26 % Ash 2.36 % Total Sulfur

1.4 Cleaned Coal: 11.65 % Ash 1.31 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,900 BTUs/pound

1.6 Cleaning Plant Yield = 61 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.57 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.73 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 2.55 /ton

$5.00/ton, additional cost is . . . . . .$ 3.20 /ton

$6.00/ton, additional cost is . . . . . .$ 3.84 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . . .$ 0.08 /ton

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 3.93 /ton

$5.00/ton, differential cost is . . . .$ 4.58 /ton

$6.00/ton, differential cost is . . . .$ 5.22 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.96 /ton

$6.00/ton, benefit is . . . .$ 1.15 /ton

$7.00/ton, benefit is . . . .$ 1.34 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 1.06 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.65 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.58 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.05 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.08 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.20 /ton

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 2.93 /ton

$6.00/ton, benefit is . . . .$ 3.12 /ton

$7.00/ton, benefit is . . . .$ 3.31 /ton

5.2 Total benefits with unit train at 0.8c/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 2.52 /ton

$6.00/ton, benefit is . . . .$ 2.71 /ton

$7.00/ton, benefit is . . . .$ 2.90 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.00	0.81	0.62
$5.00	---	1.46	1.27
$6.00	---	---	1.91

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.41	1.22	1.03
$5.00	---	1.87	1.68
$6.00	---	---	2.32

CASE # 19A

1.0 CASE CONDITIONS

1.1 Mine Location PRESTON COUNTY, WEST VIRGINIA

1.2 Consumer Location BALTIMORE, MARYLAND

1.3 Raw Coal: 14.76 % Ash 1.44 % Total Sulfur

1.4 Cleaned Coal: 6.61 % Asn 0.73 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.. Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.44 /ton

$5.00/ton, additional cost is . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 19A Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.32 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.38 /ton

$6.00/ton, benefit is . . . .$ 0.45 /ton

$7.00/ton, benefit is . . . .$ 0.53 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.39 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.15 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.18 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.14 /ton

$6.00/ton, benefit is . . . .$ 1.21 /ton

$7.00/ton, benefit is . . . .$ 1.29 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.90 /ton

$6.00/ton, benefit is . . . .$ 0.97 /ton

$7.00/ton, benefit is . . . .$ 1.05 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	0.18	0.11	0.03
$5.00	---	0.22	0.14
$6.00	---	---	0.26

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	0.42	0.35	0.27
$5.00	---	0.46	0.38
$6.00	---	---	0.50

CASE # 19B

1.0 CASE CONDITIONS

1.1 Mine Location PRESTON COUNTY, WEST VIRGINIA

1.2 Consumer Location ROCHESTER, NEW YORK

1.3 Raw Coal: 14.76 % Ash 1.44 % Total Sulfur

1.4 Cleaned Coal: 6.61 % Ash 0.73 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.44 /ton

$5.00/ton, additional cost is . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 19B Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.32 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.38 /ton

$6.00/ton, benefit is . . . .$ 0.45 /ton

$7.00/ton, benefit is . . . .$ 0.53 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.41 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.30 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.18 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8). . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 19B Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.16 /ton

$6.00/ton, benefit is . . . .$ 1.23 /ton

$7.00/ton, benefit is . . . .$ 1.31 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.05 /ton

$6.00/ton, benefit is . . . .$ 1.12 /ton

$7.00/ton, benefit is . . . .$ 1.20 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.16	0.09	0.01
$5.00	---	0.20	0.12
$6.00	---	---	0.24

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.27	0.20	0.12
$5.00	---	0.31	0.23
$6.00	---	---	0.35

CASE # 20

1.0 CASE CONDITIONS

1.1 Mine Location PRESTON COUNTY, WEST VIRGINIA

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 18.50% Ash 2.24 % Total Sulfur

1.4 Cleaned Coal: 8.85% Ash 0.99 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,300 BTUs/pound

1.6 Cleaning Plant Yield = 83 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.42 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.51 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.82 /ton

$5.00/ton, additional cost is . . . .$ 1.03 /ton

$6.00/ton, additional cost is . . . .$ 1.23 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 20 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.81 /ton

$5.00/ton, differential cost is . . . .$ 2.02 /ton

$6.00/ton, differential cost is . . . .$ 2.22 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.44 /ton

$6.00/ton, benefit is . . . .$ 0.53 /ton

$7.00/ton, benefit is . . . .$ 0.62 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.46 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.16 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.21 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.04 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.16 /ton

Case 20 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.33 /ton

$6.00/ton, benefit is . . . .$ 1.42 /ton

$7.00/ton, benefit is . . . .$ 1.51 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.03 /ton

$6.00/ton, benefit is . . . .$ 1.12 /ton

$7.00/ton, benefit is . . . .$ 1.21 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost
(per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.48	0.39	0.30
$5.00	---	0.60	0.51
$6.00	---	---	0.71

6.2 For unit train shipment

F.O.B. Raw Coal Cost
(per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.78	0.69	0.60
$5.00	---	0.90	0.81
$6.00	---	---	1.01

CASE # 21

1.0 CASE CONDITIONS

1.1 Mine Location GRANT COUNTY, WEST VIRGINIA

1.2 Consumer Location WASHINGTON, D. C.

1.3 Raw Coal: 28.48% Ash 3.03 % Total Sulfur

1.4 Cleaned Coal: 11.45% Ash 0.95 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,900 BTUs/pound

1.6 Cleaning Plant Yield = 80 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.54 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 1.00 /ton

$5.00/ton, additional cost is . . . .$ 1.25 /ton

$6.00/ton, additional cost is . . . .$ 1.50 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 21 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.03 /ton

$5.00/ton, differential cost is . . . .$ 2.28 /ton

$6.00/ton, differential cost is . . . .$ 2.53 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.73 /ton

$6.00/ton, benefit is . . . .$ 0.87 /ton

$7.00/ton, benefit is . . . .$ 1.02 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.75 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.25 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.40 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.04 /ton

4.5 Saving in benefit payment (Figure 6-8). . . .$ 0.06 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.20 /ton

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 2.18 /ton

$6.00/ton, benefit is . . . .$ 2.32 /ton

$7.00/ton, benefit is . . . .$ 2.47 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 1.68 /ton

$6.00/ton, benefit is . . . .$ 1.82 /ton

$7.00/ton, benefit is . . . .$ 1.97 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	-0.15	-0.29	-0.44
$5.00	---	-0.04	-0.19
$6.00	---	---	0.06

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.35	0.21	0.06
$5.00	---	0.46	0.31
$6.00	---	---	0.56

CASE # 22

1.0 CASE CONDITIONS

1.1 Mine Location COLUMBIANA COUNTY, OHIO

1.2 Consumer Location CHICAGO, ILLINOIS

1.3 Raw Coal: 7.00 % Ash 1.50 % Total Sulfur

1.4 Cleaned Coal: 4.00 % Ash 0.92 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,500 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.45 /ton

$5.00/ton, additional cost is . . . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.33 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.15 /ton

$6.00/ton, benefit is . . . .$ 0.17 /ton

$7.00/ton, benefit is . . . .$ 0.20 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.16 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.10 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.06 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 22 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.49 /ton

$6.00/ton, benefit is . . . .$ 0.51 /ton

$7.00/ton, benefit is . . . .$ 0.54 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.43 /ton

$6.00/ton, benefit is . . . .$ 0.45 /ton

$7.00/ton, benefit is . . . .$ 0.48 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.84	0.82	0.79
$5.00	---	0.92	0.89
$6.00	---	---	1.01

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.90	0.88	0.85
$5.00	---	0.98	0.95
$6.00	---	---	1.07

CASE # 23

1.0 CASE CONDITIONS

1.1 Mine Location CLEARFIELD COUNTY, PENNSYLVANIA

1.2 Consumer Location CHICAGO, ILLINOIS

1.3 Raw Coal: 12.4 % Ash 2.24 % Total Sulfur

1.4 Cleaned Coal: 7.4 % Ash 1.20 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 12,400 BTUs/pound

1.6 Cleaning Plant Yield = 88 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.39 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.47 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.54 /ton

$5.00/ton, additional cost is . . . .$ 0.68 /ton

$6.00/ton, additional cost is . . . .$ 0.82 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 23 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.45 /ton

$5.00/ton, differential cost is . . . .$ 1.59 /ton

$6.00/ton, differential cost is . . . .$ 1.73 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.24 /ton

$6.00/ton, benefit is . . . .$ 0.29 /ton

$7.00/ton, benefit is . . . .$ 0.33 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.29 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.21 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.10 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8). . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.12 /ton

Case 23 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.78 /ton

$6.00/ton, benefit is . . . .$ 0.83 /ton

$7.00/ton, benefit is . . . .$ 0.87 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.70 /ton

$6.00/ton, benefit is . . . .$ 0.75 /ton

$7.00/ton, benefit is . . . .$ 0.79 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.67	0.62	0.58
$5.00	---	0.76	0.72
$6.00	---	---	0.86

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.75	0.70	0.66
$5.00	---	0.84	0.80
$6.00	---	---	0.94

CASE # 24

1.0 CASE CONDITIONS

1.1 Mine Location BELL COUNTY, KENTUCKY

1.2 Consumer Location CINCINNATI, OHIO

1.3 Raw Coal: 6.50 % Ash 1.41 % Total Sulfur

1.4 Cleaned Coal: 3.00 % Ash 1.02 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 13,000 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.44 /ton

$5.00/ton, additional cost is . . . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 24 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.32 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.17 /ton

$6.00/ton, benefit is . . . .$ 0.20 /ton

$7.00/ton, benefit is . . . .$ 0.24 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.13 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.06 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.07 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 24 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.49 /ton

$6.00/ton, benefit is . . . .$ 0.52 /ton

$7.00/ton, benefit is . . . .$ 0.56 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.42 /ton

$6.00/ton, benefit is . . . .$ 0.45 /ton

$7.00/ton, benefit is . . . .$ 0.49 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.83	0.80	0.76
$5.00	---	0.91	0.87
$6.00	---	---	0.99

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.90	0.87	0.83
$5.00	---	0.98	0.94
$6.00	---	---	1.06

CASE # 25

1.0 CASE CONDITIONS

1.1 Mine Location LOGAN COUNTY, WEST VIRGINIA

1.2 Consumer Location COLUMBUS, OHIO

1.3 Raw Coal: 7.5 % Ash 1.86 % Total Sulfur

1.4 Cleaned Coal: 5.5 % Ash 1.15 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 13,200 BTUs/pound

1.6 Cleaning Plant Yield = 92 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.37 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.43 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.35 /ton

$5.00/ton, additional cost is . . . . . .$ 0.43 /ton

$6.00/ton, additional cost is . . . . . .$ 0.53 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 25 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.20 /ton

$5.00/ton, differential cost is . . . .$ 1.28 /ton

$6.00/ton, differential cost is . . . .$ 1.38 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.10 /ton

$6.00/ton, benefit is . . . .$ 0.12 /ton

$7.00/ton, benefit is . . . .$ 0.14 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.09 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.04 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.04 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ -0- /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.01 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.08 /ton

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$0.32 /ton

$6.00/ton, benefit is . . . .$0.34 /ton

$7.00/ton, benefit is . . . .$0.36 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.27 /ton

$6.00/ton, benefit is . . . .$ 0.29 /ton

$7.00/ton, benefit is . . . .$ 0.31 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.88	0.86	0.84
$5.00	---	0.94	0.92
$6.00	---	---	1.02

6.2 For unit train shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.93	0.91	0.89
$5.00	---	0.99	0.97
$6.00	---	---	1.07

CASE # 26

1.0 CASE CONDITIONS

1.1 Mine Location VIGO COUNTY, INDIANA

1.2 Consumer Location INDIANAPOLIS, INDIANA

1.3 Raw Coal: 8.5 % Ash 1.47 % Total Sulfur

1.4 Cleaned Coal: 4.4 % Ash 0.95 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,400 BTUs/pound

1.6 Cleaning Plant Yield = 85 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.41 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.50 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 0.70 /ton

$5.00/ton, additional cost is . . . . . .$ 0.88 /ton

$6.00/ton, additional cost is . . . . . .$ 1.06 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 26 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.67 /ton

$5.00/ton, differential cost is . . . .$ 1.85 /ton

$6.00/ton, differential cost is . . . .$ 2.03 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.20 /ton

$6.00/ton, benefit is . . . .$ 0.24 /ton

$7.00/ton, benefit is . . . .$ 0.28 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.09 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.03 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.09 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 26 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.51 /ton

$6.00/ton, benefit is . . . .$ 0.55 /ton

$7.00/ton, benefit is . . . .$ 0.59 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.45 /ton

$6.00/ton, benefit is . . . .$ 0.49 /ton

$7.00/ton, benefit is . . . .$ 0.53 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.16	1.12	1.08
$5.00	---	1.30	1.26
$6.00	---	---	1.44

6.2 For unit train shipment

	F.O.B. Raw Coal Cost (per ton)		
Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	1.22	1.18	1.14
$5.00	---	1.36	1.32
$6.00	---	---	1.50

CASE # 27

1.0 CASE CONDITIONS

1.1 Mine Location CALDWELL COUNTY, KENTUCKY

1.2 Consumer Location INDIANAPOLIS, INDIANA

1.3 Raw Coal: 10.0 % Ash 1.42 % Total Sulfur

1.4 Cleaned Coal: 5.5 % Ash 1.05 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,800 BTUs/pound

1.6 Cleaning Plant Yield = 80 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 1.00 /ton

$5.00/ton, additional cost is . . . . . .$ 1.25 /ton

$6.00/ton, additional cost is . . . . . .$ 1.50 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 27 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.02 /ton

$5.00/ton, differential cost is . . . .$ 2.27 /ton

$6.00/ton, differential cost is . . . .$ 2.52 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.22 /ton

$6.00/ton, benefit is . . . .$ 0.26 /ton

$7.00/ton, benefit is . . . .$ 0.30 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.15 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.10 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.09 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.10 /ton

Case 27 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.59 /ton

$6.00/ton, benefit is . . . .$ 0.63 /ton

$7.00/ton, benefit is . . . .$ 0.67 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.54 /ton

$6.00/ton, benefit is . . . .$ 0.58 /ton

$7.00/ton, benefit is . . . .$ 0.62 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.43	1.39	1.35
$5.00	---	1.64	1.60
$6.00	---	---	1.85

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	1.48	1.44	1.40
$5.00	---	1.69	1.65
$6.00	---	---	1.90

CASE # 28

1.0 CASE CONDITIONS

1.1 Mine Location CALDWELL COUNTY, KENTUCKY

1.2 Consumer Location CHICAGO, ILLINOIS

1.3 Raw Coal: 10.0 % Ash 1.42 % Total Sulfur

1.4 Cleaned Coal: 5.5 % Ash 1.05 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 11,800 BTUs/pound

1.6 Cleaning Plant Yield = 80 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.43 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.53 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . . . .$ 1.00 /ton

$5.00/ton, additional cost is . . . . . .$ 1.25 /ton

$6.00/ton, additional cost is . . . . . .$ 1.50 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.06 /ton

Case 28 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 2.02 /ton

$5.00/ton, differential cost is . . . .$ 2.27 /ton

$6.00/ton, differential cost is . . . .$ 2.52 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.22 /ton

$6.00/ton, benefit is . . . .$ 0.26 /ton

$7.00/ton, benefit is . . . .$ 0.30 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . .$ 0.21 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.14 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.09 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . . .$ 0.01 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.02 /ton

4.6 Estimated maintenance saving (Table 6-3). . . .$ 0.10 /ton

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.65 /ton

$6.00/ton, benefit is . . . .$ 0.69 /ton

$7.00/ton, benefit is . . . .$ 0.73 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.58 /ton

$6.00/ton, benefit is . . . .$ 0.62 /ton

$7.00/ton, benefit is . . . .$ 0.66 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	1.37	1.33	1.29
$5.00	---	1.58	1.54
$6.00	---	---	1.79

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton) $5.00	$6.00	$7.00
$4.00	1.44	1.40	1.36
$5.00	---	1.65	1.61
$6.00	---	---	1.86

CASE # 29

1.0 CASE CONDITIONS

1.1 Mine Location FRANKLIN COUNTY, ILLINOIS

1.2 Consumer Location ST. LOUIS, MISSOURI

1.3 Raw Coal: 17.0 % Ash 1.25 % Total Sulfur

1.4 Cleaned Coal: 10.0 % Ash 0.95 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 10,800 BTUs/pound

1.6 Cleaning Plant Yield = 88 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.39 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.47 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.53 /ton

$5.00/ton, additional cost is . . . .$ 0.68 /ton

$6.00/ton, additional cost is . . . .$ 0.82 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . . .$ 0.05 /ton

Case 29 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.44 /ton

$5.00/ton, differential cost is . . . .$ 1.59 /ton

$6.00/ton, differential cost is . . . .$ 1.73 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.33 /ton

$6.00/ton, benefit is . . . .$ 0.39 /ton

$7.00/ton, benefit is . . . .$ 0.46 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.20 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.05 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8) . . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 29 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.87 /ton

$6.00/ton, benefit is . . . .$ 0.93 /ton

$7.00/ton, benefit is . . . .$ 1.00 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.72 /ton

$6.00/ton, benefit is . . . .$ 0.78 /ton

$7.00/ton, benefit is . . . .$ 0.85 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.57	0.51	0.44
$5.00	---	0.66	0.59
$6.00	---	---	0.73

6.2 For unit train shipment

F.O.B. Raw Coal Cost (per ton)

Raw Coal Value (per ton)	$5.00	$6.00	$7.00
$4.00	0.72	0.66	0.59
$5.00	---	0.81	0.74
$6.00	---	---	0.88

CASE # 30

1.0 CASE CONDITIONS

1.1 Mine Location FRANKLIN COUNTY, ILLINOIS

1.2 Consumer Location CHICAGO, ILLINOIS

1.3 Raw Coal: 17.0 % Ash 1.25 % Total Sulfur

1.4 Cleaned Coal: 10.0 % Ash 0.95 % Total Sulfur

1.5 Heat Content of Cleaned Coal: 10,800 BTUs/pound

1.6 Cleaning Plant Yield = 90 %

1.7 Cleaning Plant Cost: $8,000 per ton hour input capacity. (Amortized over ten years, 8% interest on unpaid balance.)

1.8 Cleaning Plant Utilization: 260 days/yr at 13 hrs/day (i.e., 38.5%)

2.0 COST FACTORS

2.1 Amortization Cost (Figure 5-3). . . . .$ 0.38 /ton

2.2 Operation and Maintenance Cost (Figure 5-4) .$ 0.45 /ton

2.3 "Additional" raw coal value to provide for one ton of cleaned coal (Figure 5-5) when value of raw coal is -

$4.00/ton, additional cost is . . . .$ 0.44 /ton

$5.00/ton, additional cost is . . . .$ 0.55 /ton

$6.00/ton, additional cost is . . . .$ 0.67 /ton

2.4 Cleaning Plant Tax Burden (Figure 5-6). . . .$ 0.05 /ton

Case 30 Continued

3.0 TOTAL DIFFERENTIAL PRODUCTION COST TO PROVIDE A TON OF CLEANED COAL

When value of raw coal is -

$4.00/ton, differential cost is . . . .$ 1.32 /ton

$5.00/ton, differential cost is . . . .$ 1.43 /ton

$6.00/ton, differential cost is . . . .$ 1.55 /ton

4.0 ASSESSABLE BENEFIT FACTORS ASSOCIATED WITH CLEAN COAL

4.1 Added coal value due to higher heat content of Coal (Figure 6-1). When F.O.B. Raw Coal Cost is -

$5.00/ton, benefit is . . . .$ 0.33 /ton

$6.00/ton, benefit is . . . .$ 0.39 /ton

$7.00/ton, benefit is . . . .$ 0.46 /ton

4.2 Transportation cost saving due to increased heat content of coal. (Saving equals applicable rate · K, Figure 6-2)

Saving on single car shipment . . . . . .$ 0.27 /ton

Saving on unit train shipment @ 0.80¢/ton mile . . . .$ 0.16 /ton

4.3 Saving in ash disposal cost/ton burned (based on ash disposal cost = $2/ton)(Figure 6-6)$ 0.15 /ton

4.4 Saving in grinding cost (Figure 6-7). . . . .$ 0.02 /ton

4.5 Saving in benefit payment (Figure 6-8). . . .$ 0.03 /ton

4.6 Estimated maintenance saving (Table 6-3). . .$ 0.14 /ton

Case 30 Continued

5.0 TOTAL BENEFITS ASSESSMENT

5.1 Total benefits with single car shipment rate. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.94 /ton

$6.00/ton, benefit is . . . .$ 1.00 /ton

$7.00/ton, benefit is . . . .$ 1.07 /ton

5.2 Total benefits with unit train at 0.8¢/ton mile. When F.O.B. raw coal cost is -

$5.00/ton, benefit is . . . .$ 0.83 /ton

$6.00/ton, benefit is . . . .$ 0.89 /ton

$7.00/ton, benefit is . . . .$ 0.96 /ton

6.0 SUMMARY

Differential Cost (Cleaning Costs less Benefits) per Ton

6.1 For single car shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.38	0.32	0.25
$5.00	---	0.43	0.36
$6.00	---	---	0.48

6.2 For unit train shipment

Raw Coal Value (per ton)	F.O.B. Raw Coal Cost (per ton)		
	$5.00	$6.00	$7.00
$4.00	0.49	0.43	0.36
$5.00	---	0.54	0.47
$6.00	---	---	0.59

APPENDIX VII

COST/BENEFIT ANALYSIS MODEL

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APPENDIX VII

COST/BENEFIT ANALYSIS MODEL

1.0 PURPOSE AND SCOPE

The purpose of this computerized cost/benefit analysis model is to examine the net economic effect resulting from the production and utilization of cleaned coal. As indicated in Sections 4.0, 5.0, and 6.0, all the economic factors bearing on the evaluation are variable and must be quantified for specific conditions.

The general structure of the cost/benefit analysis model consists of three basic elements:

- Clean Coal Source
- Transportation
- Clean Coal User

Essentially the model develops the production cost of cleaning coal at a mine, taking into account the cost variation in transporting clean coal to the user and finally applying the cost savings to the user to achieve a net economic result.

The variable economic factors discussed in Sections 4.0, 5.0, and 6.0 may be grouped according to these three elements in the following manner:

- Clean Coal Source
  - A. Coal composition before and after cleaning (sulfur and ash)
  - B. Cleaning plant amortization costs
  - C. Cleaning plant operation and maintenance costs
  - D. Additional coal costs
  - E. Tax burden

- Transportation
    - A. Clean coal source location (county)
    - B. Clean coal user location
    - C. Transportation method
    - D. Transportation cost savings as a result of increased heat content
- Clean Coal User
    - A. Increase in coal value as a result of increased heat content
    - B. Ash disposal cost savings
    - C. Grinding cost savings
    - D. Welfare payment savings
    - E. Maintenance cost savings

A computer program for this model was developed to perform the computations required for clean coal cost/benefit analyses. The program provides for analysis flexibility by accepting each quantified economic variable as an input condition.

2.0 COMPUTER PROGRAM DESCRIPTION

The symbols used in the cost/benefit analysis program are explained in the following list:

Definition of Program Symbols

Symbol	Value	Units	Definition
YIELD	Data Input		Yield of cleaning plant (Output/Input)
COST	Data Input	\$/ton-hr	Cleaning plant cost per ton-hour input capacity
HOUR	Data Input	hr	Utilization of cleaning plant in hours/year
ROM	Data Input	\$/ton	Raw Coal Value (Cost to provide raw coal)
RATE	Data Input		Cleaning plant interest rate on unpaid balance
PERIOD	Data Input	yrs	Cleaning plant amortization period
COAL	Data Input	\$/ton	F.O.B. raw coal cost
SHIP	Data Input	\$/ton	Shipping cost from mine to consumer
ASH	Data Input	\$/ton	Cost of disposing ash by coal user
PSULB	Data Input		Fractional sulfur content of raw coal (by weight)
PSULA	Data Input		Fractional sulfur content of deep-cleaned (by weight)
PASHB	Data Input		Fractional ash content of raw coal (by weight)
PASHA	Data Input		Fractional ash content of deep-cleaned (by weight)
GRIND	=0.25	\$/ton	Cost to user of grinding coal
WEL	=0.40	\$/ton	Mine contribution to welfare fund per ton shipped
PN	=12 x PERIOD	months	Cleaning plant amortization period

BTU	=PASHB - PASHA		Fractional decrease in ash content of coal due to deep cleaning (i.e., fractional increase in BTU value)
RED	=PSULB - PSULA +PASHB - PASHA		Fractional reduction in sulfur plus ash content of coal due to deep cleaning
OM	Y	\$/ton	Cleaning plant operation and maintenance cost per ton of clean coal
X	.7 .8 .9 1.0		Table of yield values for cleaning plant
Y	.64 .54 .453 .377	\$/ton	Cleaning plant operating and maintenance costs corresponding to X
SM	TAB2	\$/ton	Assumed savings in maintenance due to reduction in sulfur plus ash content
TAB1	=.15 .12 .09 .07 .05 .03 .02		Table of fractional reductions in sulfur plus ash content
TAB2	=.16 .14 .12 .10 .08 .05 .03	\$/ton	Assumed maintenance savings corresponding to TAB2
TERM	$= (1 + \frac{RATE}{12})^{PN}$		A term in the amortization equation (see Equation 1 (1) below)
ACOST	Equation 1	\$/ton	Total additional costs due to deep cleaning
BEN	Equation 2	\$/ton	Total additional benefits due to deep cleaning

The operation of the cost/benefit analysis program is summarized by the following equations:

Equation 1 - Additional Costs

The additional cost (ACOST) is a summation of the following items:

- Cleaning Plant Amortization Cost

$$12 \times \text{RATE} \times \frac{\left(1 + \frac{\text{RATE}}{12}\right)^{\text{PN}}}{\left(1 + \frac{\text{RATE}}{12}\right)^{\text{PN}} -1} \times \frac{\text{COST}}{\text{HOUR} \times \text{YIELD}} \qquad (1)$$

- Cleaning Plant Operation and Maintenance Cost (OM)

  OM is computed by interpolation

$$\text{OM} = Y_{i-1} - \frac{Y_{i-1} - Y_i}{X_{i-1} - X_i} \left(X_{i-1} - \text{YIELD}\right) \qquad (2)$$

where i is the smallest i such that $\text{YIELD} \leq X_i$

- Additional cost of coal

$$\text{ROM} \times \frac{(1 - \text{YIELD})}{\text{YIELD}} \qquad (3)$$

- Tax Burden

$$\frac{\text{COST} \times 0.02}{\text{HOUR} \times \text{YIELD}} \qquad (4)$$

Equation 2 - Benefits

The benefit (BEN) is a summation of the following items:

- Increase in coal value due to increased BTU content

$$\mathrm{COAL} \times \frac{\mathrm{BTU}}{1 + \mathrm{BTU}} \tag{5}$$

- Shipping cost saving

$$\mathrm{SHIP} \times \frac{\mathrm{BTU}}{1 + \mathrm{BTU}} \tag{6}$$

- Ash disposal cost saving

$$\mathrm{ASH} \times \mathrm{BTU} \times (1 + \mathrm{BTU}) \tag{7}$$

- Grinding cost saving

$$\mathrm{GRIND} \times \frac{\mathrm{BTU}}{1 + \mathrm{BTU}} \qquad \text{where GRIND} = .25 \tag{8}$$

- Welfare payment saving

$$\mathrm{WEL} \times \frac{\mathrm{BTU}}{1 + \mathrm{BTU}} \qquad \text{where WEL} = .40 \tag{9}$$

- Maintenance cost saving (SM)

SM is computed by table lookup

$$\mathrm{SM} = \mathrm{TAB2}_i \qquad \text{where } i \text{ is the smallest } i \text{ such that } \mathrm{RED} \geq \mathrm{TAB1}_i \tag{10}$$

3.0 COMPUTER PROGRAM APPLICATION

The performance of the program was evaluated by application to the potential clean coal source/user combinations described in Section 7.0 and summarized by manual computation in Volume II. The following are two examples of the results achieved:

- INPUT CONDITIONS

Example No. 1

Mine Location Allegany County, Md.

Consumer Location Baltimore

Raw Coal 20.3% Ash; 1.13% Total Sulfur

Cleaned Coal 13.1 % Ash; 1.06% Total Sulfur

Cleaning Plant Cost (assumed) . . . .$8,000 per ton hour cap. (Amortized over 10 years, 8% interest on unpaid balance)

Raw Coal Value = $4.00 per ton

F.O.B. Raw Coal Cost = $5.00/ton

Transportation Cost = $5.17 per ton

Ash Disposal Cost = $2.00 per ton

Yield = 90%

Example No. 2 (Case 1A)

This example differ from Example No. 1 in the following manner:

Raw Coal Value = $6.00 per ton

F.O.B. Raw Coal Cost = $7.00/ton

Yield = 80%

- **COMPUTER OUTPUT**

Example No. 1

```
ENTER INPUT DATA
YIELD,COST,HOUR,ROM
= .9,8000,3380,4
RATE,PERIOD
= .08,10
COAL,SHIP,ASH
= 5,5.17,2
PSULB,PSULA,PASHB,PASHA
= .0113,.0106,.203,.131
COSTS     =       1.33
BENEFITS =       0.99
NET COST =       0.35
ANOTHER CASE ?
TYPE 1 FOR YES OR 0 FOR NO
= 1
```

Example No. 2 (Case 1A)

```
ENTER INPUT DATA
YIELD,COST,HOUR,ROM
= .81,8000,3380,6
RATE,PERIOD
= .08,10
COAL,SHIP,ASH
= 7,5.17,2
PSULB,PSULA,PASHB,PASHA
= .0113,.0106,.203,.131
COSTS     =       2.42
BENEFITS =       1.12
NET COST =       1.30
ANOTHER CASE ?
TYPE 1 FOR YES OR 0 FOR NO
= 0
```

- COMPUTER PROGRAM LISTING

```
10 DIMENSION TAB1(7),TAB2(7)
20 DIMENSION X(4),Y(4)
30 TAB1(1) = .15
40 TAB1(2) = .12
50 TAB1(3) = .09
60 TAB1(4) = .07
70 TAB1(5) = .05
80 TAB1(6) = .03
90 TAB1(7) = .02
100 TAB2(1) = .16
110 TAB2(2) = .14
120 TAB2(3) = .12
130 TAB2(4) = .10
140 TAB2(5) = .08
150 TAB2(6) = .05
160 TAB2(7) = .03
170 Y(1) = .64
180 Y(2) = .54
190 Y(3) = .453
200 Y(4) = .377
210 X(1) = .7
220 X(2) = .8
230 X(3) = .9
240 X(4) = 1.0
250 4 FORMAT (V)
260 10 PRINT 200
270 PRINT 201
280 200 FORMAT (" ENTER INPUT DATA ")
290 201 FORMAT (" YIELD,COST,HOUR,ROM")
300 READ 4,YIELD,COST,HOUR,ROM
310 PRINT 202
320 202 FORMAT (" RATE,PERIOD")
330 READ 4,RATE,PERIOD
340 PRINT 203
350 203 FORMAT (" COAL,SHIP,ASH")
360 READ 4,COAL,SHIP,ASH
370 PRINT 204
380 204 FORMAT (" PSULB,PSULA,PASHB,PASHA")
390 READ 4,PSULB,PSULA,PASHB,PASHA
400 GRIND = 0.25
410 WEL = 0.50
420 TAX = .02
430 PN = PERIOD*12.
440 BTU = PASHB - PASHA
450 IF (YIELD-X(1)) 11,11,12
460 11 OM = Y(1)
470 GO TO 18
480 12 DO 13 I=2,4
490 IF (YIELD-X(I)) 15,15,13
500 13 CONTINUE
510 OM = Y(4)
```

*

```
520 GO TO 18
530 15 OM = Y(I-1) - ((Y(I-1)-Y(I))/(X(I-1)-X(I)))
540&  *(X(I-1)-YIELD)
550 18 RED = PSULB-PSULA + PASHB-PASHA
560 DO 20 I=1,7
570 IF (RED-TAB1(I)) 20,23,23
580 20 CONTINUE
590 SM = 0.
600 GO TO 25
610 23 SM = TAB2(I)
620 25 RATE = RATE/12.
630 TERM = (1.+RATE)**(PN/2)
640 TERM = TERM*TERM
650 ACOST = ROM*(1.-YIELD)/YIELD + OM
660&  + 12.*RATE*TERM/(TERM-1.) * (COST/(HOUR*YIELD))
670&  + COST*TAX/(HOUR*YIELD)
680 PRINT 5,ACOST
690 5 FORMAT (" COSTS    = ",F9.2)
700 BEN = BTU/(BTU+1.)*(COAL+SHIP+GRIND+WEL)
710& + ASH*BTU*(1.+BTU) + SM
720 PRINT 6,BEN
730 6 FORMAT (" BENEFITS = ",F9.2)
740 ACOST = ACOST-BEN
750 PRINT 7,ACOST
760 7 FORMAT (" NET COST = " ,F9.2)
770 PRINT 8
780 8 FORMAT (" ANOTHER CASE ? ")
790 PRINT 81
800 81 FORMAT (" TYPE 1 FOR YES OR 0 FOR NO")
810 READ 9,M
820 9 FORMAT (I1)
830 IF (M) 100,100,10
840 100 STOP
850 END

READY

*
```